This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

GENERAL LIBRARY
OF
University of Michigan
Presented by
Geol. Survey of New Jersey
Feb. 3, 1902

QE
14
A25

GENERAL LIBRARY

OF

University of Michigan

Presented by

Geol. Survey of New Jersey
Feb. 3, 1902

A25

GEOLOGICAL SURVEY OF NEW JERSEY

ANNUAL REPORT

OF THE

STATE GEOLOGIST

For the Year 1899

TRENTON, N. J.:
MacCrellish & Quigley, State Printers, Opposite Post Office.
1900.

Page
PART III.—Chlorine in the Natural Waters, by William S. Myers, . 141
Introductory, ... 143
Tables of Analyses of Waters, ... 145

PART IV.—The Mining Industry.
I. Report on Iron Mines, by George E. Jenkins, ... 151
Review of the Iron Mining Industry, ... 151
Iron Mines, ... 152
Analyses of Iron Ores, ... 165
II. Notes on Copper Mines, by Henry B. Kümmel, ... 171

MINERAL STATISTICS, ... 177
PUBLICATIONS, ... 181
INDEX, ... 187

ILLUSTRATION.

Page
PLATE I.—Cambrian Trilobites, face, ... 53

Board of Managers.

HIS EXCELLENCY FOSTER M. VOORHEES, Governor, and *ex-officio* President of the Board, ... TRENTON.

I. Congressional District.

EDWARD C. STOKES, ... MILLVILLE.
CLEMENT H. SINNICKSON, ... SALEM.

II. Congressional District.

EMMOR ROBERTS, ... MOORESTOWN.
WASHINGTON A. ROEBLING, ... TRENTON.

III. Congressional District.

HENRY S. LITTLE, ... MATAWAN.
M. D. VALENTINE, ... WOODBRIDGE.

IV. Congressional District.

FREDERICK A. CANFIELD, ... DOVER.
GEORGE RICHARDS, ... DOVER.

V. Congressional District.

GEORGE W. WHEELER, ... HACKENSACK.
WILLIAM F. HALL, ... POMPTON LAKES.

VI. Congressional District.

THOMAS T. KINNEY, ... NEWARK.
FREDERIC W. STEVENS, ... NEWARK.

VII. Congressional District.

LEBBEUS B. WARD, ... JERSEY CITY.
SAMUEL B. DOD, ... HOBOKEN.

VIII. Congressional District.

ERNEST A. ACKERMAN, ... PLAINFIELD.
WENDELL P. GARRISON, ... ORANGE.

To His Excellency Foster M. Voorhees, Governor of the State of New Jersey, and ex-officio President of the Board of Managers of the Geological Survey:

SIR—I have the honor to present herewith the Annual Report of the Geological Survey for 1899.

Respectfully submitted,

JOHN C. SMOCK,
STATE GEOLOGIST.

TRENTON, N. J.,
November 29th, 1899.

Administrative Report.

The work of the Geological Survey in 1899 has been done conformably to the plan proposed at the beginning of the year, and the investigations in the several divisions have been in the same general direction as carried forward last year. The survey of the surface formations has been in the charge of Prof. Rollin D. Salisbury, and he has been assisted by G. N. Knapp. The survey of the Paleozoic formations has been begun this year, and Mr. Stuart Weller has had charge of this work. He has had Mr. Kümmel as associate in the study of the structural relations of these rocks of the Paleozoic System. The topographic work of the Survey has been directed by Mr. C. C. Vermeule, who has also given some time to the examination of the forest conditions of the State and the preparation of the report on forestry. Mr. Peter D. Staats has been the field assistant, and J. R. Prince, draughtsman. The record of artesian wells has been continued by Lewis Woolman. Mr. Irving S. Upson has remained in charge of the distribution of the topographic maps, and has acted as disbursing officer to the Survey.

At the summer meeting of the Board of Managers Mr. Henry B. Kümmel was appointed on the staff of the Survey, and since the close of the field season he has had charge of the office work as Assistant State Geologist.

The results and the scope of the investigations and surveys of the several divisions and their relation to the general direction of the work of the Geological Survey and to the economic development of the State are stated in order, under their several heads, in this administrative report.

SURFACE GEOLOGY.

The survey of the surface formations has been directed by Prof. Rollin D. Salisbury. This study of the formations which make the surface of the country is related closely to what is known as the physical geography or as the physiography, but it includes the investigations which have for their object the nature of the materials, as well as the study of the form or configuration of the surface formations. The physical geography of the State has been described in the last volume published by the Geological Survey.[*] This report on the physical geography may be considered as the first volume on the geology of the surface. The work of Professor Salisbury has been in progress since 1891, and many of the results of his investigations have been given in the annual reports, besides the volume on the physical geography.[†] The field work is about done and the preparation of the report on the studies and surveys is in part done. The publication is to be in two parts, one descriptive of the northern part of the State, the other of the southern part. By this plan the distribution will be made to the convenience of localities and will avoid needless excess in sending out the volumes of the Survey. The report on the Surface Geology will cover the descriptions of the sands, gravels, clays, marls and earthy beds, and also of the rock outcrops which make the surface of the State; the relation of these beds to the underlying strata or beds; the history of their origin, or source of materials; their geological age and the correlation with the surface formations of the States of our Middle Atlantic coast; and the value of these facts, as they bear on the origin and nature of the soil, the varieties of trees and the subject of forestry and the occurrence of ores, clays, sands, marls, peat and other crude materials which are of use in the arts. The full discussion of the nature and extent of these surface formations is related closely to the geology of the rocks beneath the surface, or the under geology, and the report will include many facts of the latter division of the general geology of the State. On this account it seems to be desirable to give with the maps of the surface formations those of the underlying formations in the same publication, or at least so much as shall give all the facts of economic importance.

As was stated in the last annual report, the maps which are to accompany this report are to be in sections, or sheets, joining edge to edge and not overlapping as in the old topographic series. The scale, as proposed, is that of the latter series—one inch to one mile—and the sheets are to correspond in form and arrangement to the new maps, of which four sheets are already published. Four of these new and large-scale maps cover the same territory as one of the geological series, but of course on a larger scale. This scheme for the State requires thirty-four sheets, or twice the number of the topographic series. For some parts of the State where there are valuable deposits of ores and minerals and also in the thickly-settled suburban districts, the new topographic series of maps may be used as the base for the exhibition of the geological features and the location and extent of valuable ores and other materials of use. The large-scale maps will be of service in the localities which they show, particularly if they have with the maps descriptive text and notes on the geologic structure. This plan of publication by the United States Geological Survey has proven attractive and of great value and the sales of their geologic folios are large. Some plan of this kind seems to be necessary in order to give all the necessary facts of localities and put them within the reach of all who may want them. In this way every locality would have a particular interest in a particular map or folio, and every one would have, as it were, its own special report and map; and all, taken as a whole and in their geographic order of arrangement, would make an atlas of the State, and the chapters of the geology in detail would give that for the State. The economy in both publication and in distribution is for this plan of sectional maps or folios. The results of the surveys made by Professor Salisbury and his assistants can be put in the hands of the people in the two volumes of this report on the Surface Geology, and within the next fiscal year, or at furthest, two years.

---

[*] Report on the Physical Geography of New Jersey, Vol. IV of the Final Report of the State Geologist, Trenton, 1898.

[†] Annual Report of State Geologist for 1891, pp. 35-108; 1892, pp. 33-166; 1893, pp 33-328; 1894, pp. 1-149; 1895, pp. 1-16; 1896, pp. 1-23; 1897, pp. 1-22; 1898, pp. 1-41

The small-scale maps may illustrate the report sufficiently in detail. The publication of the geological atlas must occupy a longer period, because of the cost of the maps and the time needed for their preparation.

During the year Professor Salisbury has been assisted by G. N. Knapp, both in the survey and in the preparation of two atlas sheets—Newark and Camden—submitted with this report. In the northern part of the State Mr. Kümmel did some field-work late in the season on large-scale maps of local features, and the results of his surveys are to be used in the report on the Surface Geology.

Professor Salisbury's report on the work is here appended. It is a clear and concise summary and statement of plans for the publication of his work in the State.

In connection with the work on the surface formations under the direction of Professor Salisbury, four typical areas were surveyed in detail by Mr. Kümmel, and maps, on a large scale, prepared by the topographical division of the Survey, were used for the delineation of the several surface formations and their characteristic topography. One of these areas is near Hackettstown, and is a section of the terminal moraine of the last glacial epoch. The map represents the older glacial drift and the terminal moraine, and shows their relative positions and their relation to the older formations, and the soils resulting from the disintegration of these older rocks.

Another area is southwest of Newton, in Sussex county, and embraces a territory of eight square miles. Glacial deposits, unstratified and stratified, are here interlocked with knobs of limestone and slate ridges and the surface is marked by great diversity. The hills of limestone and the patches of till, or unsorted drift, rise as islands above the plains of stratified sand and gravel. The latter are in farms and under cultivation, whereas the rocky ledges of limestone are nearly all wooded. The deep depressions or *kettles* which occur in the gravel plains are characteristic features, and mark the places where blocks and large masses of ice melted at the close of the glacial epoch. The Newton area has been mapped on a scale of 1 inch to 400 feet, and the contour lines have been shown at intervals of 5 feet.

At Ogdensburg, in Sussex county, a large triangular bank of drift, which stretches nearly across the Wallkill valley, was surveyed and mapped on a scale of 1 inch to 200 feet.

The fourth area is a mass of glacial drift in great hills between Hamburg and Franklin Furnace. The map, on a scale of 1 inch to 800 feet and having contour lines 10 feet apart, covers about five square miles. The features of the topography shown by this map are a glacial delta and enormous kames. The lobed front of the great delta, where it was deposited in water, is in contrast with the hummocky surface back where the gravel was deposited against the irregular ice front. The kames are remarkable for their size, surpassing any known elsewhere in the State.

These four maps of typical areas of glacial formations will make valuable illustrations for Professor Salisbury's report on the Surface Geology, showing in great detail the work of the glacier in depositing the till, or drift under its mass, the terminal moraine at its extreme limit or front, and of the waters in forming deltas, and in modifying the deposits laid down by the glacier.

PALEOZOIC FORMATIONS.

The necessity of a re-survey and of a geological map of the Paleozoic formations of the State has been recognized for a long time. These older rock-formations are found in the valleys of the Highlands and along its borders, both southeast and northwest; in the Kittatinny valley, in the Kittatinny mountain and the valley of the Delaware from Carpenter's Point to Walpack Bend, and in the Green Pond, Copperas and Bearfort mountain ranges. The rocks are in strata, which lie horizontally in places, but are generally upturned at high angles, and are folded and broken by faulting, showing the results of great change in position since they were laid down as sediments in the estuaries or oceans of Paleozoic time. They are conglomerates, sandstones, quartzites, shales, limestones, slates and, in places, they are metamorphosed and sub-crystalline in texture. In his "Final Report," published in 1840, Prof. Henry D. Rogers described these formations as Lower Secondary or Appalachian Rocks. Dr. Kitchell referred to them in his reports in 1854 and 1855. In the "Geology of New Jersey," 1868, the late State Geologist, Professor Cook, described them in detail, so far as their limits, thickness, structural relations of the beds and nature of the rocks were concerned, but little attention was given to the study of the fossilized forms of life in them.* Early in the season Mr. Stuart Weller, of the University of Chicago, was engaged to study these formations, to map their outcrops, and to prepare a report on the geologic structure and on the paleontologic characters. Mr. Weller was in the field from the first of July to the end of September. He was assisted a part of August and in September by Mr. Kümmel.

---

* Geology of New Jersey, 1868, pp. 70–167.

The work of the season has been in part a reconnoissance of the Kittatinny valley, and in part a detailed survey of the valley of the upper Delaware. The results of the reconnoissance show the existence of limestones of the Trenton period, lying generally at the margin of the blue magnesian limestone and near the slate rocks; conglomerate beds at the base of these Trenton beds, which contain pebbles of the magnesian limestone, and the presence of fossils (trilobites) in the magnesian limestone beds at Carpentersville, on the Delaware, which indicate their geological age as Cambrian.

The discovery of fossils in the magnesian limestone at Carpentersville is noteworthy, because in all the extent of this formation so little evidence of life has been found that it has been regarded as generally barren of life. The fossils indicate the Cambrian age of the magnesian limestone in part at least, and also of the Hardystonville quartzite. The work of next year in the Kittatinny valley will, in all probability, yield further localities of fossils, and afford evidence as to the age of the whole magnesian limestone series of beds, and the associated conglomerates and quartzites which are at its upper edge and at its base respectively.

The survey of the upper Delaware valley was carried out in detail, and the several formations were traced in their outcrops from the New York line, near Port Jervis, to the Delaware river, at Walpack bend. Some work was done southwest of the Walpack bend and in tracing the extension of these formations in Pennsylvania. The geological structure was studied and a geological map on the base of the topographic survey was drawn, showing the limits of the several formations of limestone, shale, sandstone and slaty rocks.

These formations make the massive ridge which lies between the Delaware river, on the northwest, and the valleys of Flatbrook and Millbrook, which separate it from the main slope of the Kittatinny mountains on the southeast side. The topographic features are marked, and this valley, from one-eighth to one mile in breadth, is one of them. The drift material in the bottom conceals the adjacent formation at the southeast, but it is almost certainly the Medina sandstone, the rock of the western slope of the Kittatinny mountain. The strata of the ridge dip generally to the northwest and their edges are exposed in the steep southeastern face, so that in crossing over it, in a northwestern direction, the beds are passed over in an ascending order. The large quarry on the Nearpass place, in Montague, affords the best section of the strata, and from near the base of the ridge to its crest. It was the key to the descriptions by Doctor Cook, in the "Geology of New Jersey," but owing to an error in correlating the so-called "ribbon limestone" of this locality with a formation lying upon the water-lime beds at Rondout, on the Hudson, the exact geologic horizon was not interpreted aright. The investigations of Mr. Weller show further that there are more subdivisions than were given in the report in 1868. He has found the following in ascending order from valley of the Flatbrook to the Delaware river:

Poxino Island shale,	Silurian System.
Bossardville limestone,	
Decker Ferry limestone,	
Rondout water limestone,	
Manlius limestone,	Devonian System.
Coeymans limestone,	
New Scotland beds,	
Stormville sandstone,	
Becraft limestone	
Esopus grits,	
Onondaga limestone,	

These names are from the localities in New York and Pennsylvania where the formations are represented by characteristics which are marked, and hence give the basis for naming them from these typical localities. The fossil species and the order of succession afford the evidence of identification in New Jersey. The readers of the report of 1868 may recognize the "Ribbon limestone" in the Bossardville limestone of Mr. Weller's report; the "peth stone" as the Rondout water-lime. The Lower Pentamerus is now known as the Coeymans limestone and the "Cauda Galla grit" as Esopus grits.

The groups of these formations are in what is known as the Silurian System, which follows the Cambrian, and in the Devonian, which is the next later in geological succession. The slates, conglomerates and sandstones of the Kittatinny mountain belong to the earlier periods of the Silurian; then come the subdivisions of the later Silurian, ending with the water-lime; next the Devonian, which includes the Marcellus shale and the Hamilton rocks, which form the hills across the Delaware in Pennsylvania. The Carboniferous System, including the Coal Measures, follows the Devonian in order of time, and all these are parts of what geologists term Paleozoic time.

From the nature of the rocks and the fossil forms characteristic of them the geologic history is read, and the changes in the relations of the water to land are revealed by the succession of animals whose remains mark the formations. The history is one of rather frequent changes in the conditions of the water and land, and yet they must have been gradual, as is in evidence from the transitional formations, as that of the Rondout water-lime, which was a period of land-locked seas or shut-in seas, and with fresh-water or non-marine forms of life in its waters, following the marine-life conditions of the Decker Ferry formations and succeeded by the epi-continental seas of the Manlius period at the beginning of the Devonian. The Medina sandstone was an earlier epoch of transition.

The changes in the rocks also show, as do those of the fossil forms, altered conditions, the limestones marking the deeper sea deposits, the shales, the sediments off-shore and the sandstones and grits, shore or littoral deposits. All are proof of the great length of time necessary for deposition of these sediments and the changes in the conditions indicated by these differences in rocks and their imbedded forms of life. This report is one of the chapters in the earlier geological history of the State, and in its record of invertebrate life is most interesting because of the abundance and the variety of form. Mr. Weller's studies enable us to recognize the succession of life and afford evidence for the accurate identification of any given horizon. The position of each member in the series is thereby determined and the succes sion of the strata in any section or part of the ridge is made known.

The value of the map and the report to the economic development of the valley of the Delaware will be in the accurate determination of the place of valuable beds of limestone, both for building purposes and for lime manufacture, and of the water-lime for cement, and of the shales and grits in their relations to the soils and to agriculture and forestry. The contribution to our scientific knowledge and the accurate exposition of the geological structure and the life history of these formations make this first report on the Paleozoic formations of the State suggestive of important results and of value as the survey is continued.

ARTESIAN WELLS.

The record of deep-bored wells in the State has been in the charge of Lewis Woolman, of Philadelphia, who has made reports yearly since 1890. He has visited many of the localities and has collected a large number of specimens of gravels, sands, clays, marls and other earthy materials which have been obtained from these borings. They show the nature of the beds which are passed through in the well-boring, and they make an important addition to the collections made by Mr. Woolman and which have been placed in the Geological Survey Museum. Valuable information has been given by the several well-drilling firms and by their superintendents and foremen about the depth, thickness of the different beds passed through, the nature of the materials, position of the water-bearing beds, flow of water and other facts. The data have been used by Mr. Woolman in his studies on the water-horizons and their relation to the geologic structure of the country, particularly in the southern part of the State, and in the Cretaceous, Tertiary and Post-Tertiary formations. The well-borings of the year confirm the existence of certain well-defined horizons or water-bearing beds which have been described in the Annual Reports for 1897 and 1898, and which have been given names from localities where they have been found in wells. The more open or porous beds, as gravel and sand, are full of water and are water-bearing horizons, whereas the tight and dense materials, as clay and some of the greensand marls, are not water-bearing, but are impervious and prevent the flow of water through them. As is well known in the greensand-marl districts of the State, there are springs of water issuing from the upper surface or where the top earth or *stripping* rests on the marl beds and not in the marl itself. And at the bottom, when the digging has reached the sandy beds under the marl, the water comes in freely in the pits whence the marl has been taken. The borings for water, as they pass through these dense and tight beds of marl or of clay and strike the more open sands or gravels, give vent to the head of water, and it flows to the surface or nearly up to the top of the well. In some cases there are hard and stony layers, made by a cementation of the sand by oxide of iron, which prevent the rise of the water; in others, a calcareous or lime-cemented bed is the impervious stratum which prevents the passage of the water.

Mr. Woolman has given names to the well-marked water-horizons in the southern part of the State, but it is not necessarily true that they are the sole water-bearing ones. Our knowledge of the geological structure is not yet sufficiently comprehensive in all the details of localities to assume that the classification, as reported, is exclusive of the existence of others. On the contrary, it is almost certain that further study and the data to be had from many localities where there are no bored wells will make it necessary to modify the scheme and to add other horizons. Hence the need of continuing the work of gathering notes of well-borings is urgent, in order to an accurate knowledge of the sources of the well-supply, and not in the southern part of the State only, but in the northern part also, and in the rocky strata of the older formations.

The records of the wells are arranged in the geological order of succession, and under the heads Cretaceous, Miocene and Post-Miocene. Among the notable discoveries shown by the borings are: The existence of the Raritan clays at 45 feet below the surface, and down to 102 feet, in wells southeast of Pedricktown, in Salem county; the *Woodbury-Wenonah* horizon, near Mickleton, in Gloucester county; the Raritan clays, at 290–340 feet, at Colestown, in Burlington county; the red clays (Raritan formation) at East Burlington; the clays in the well at Columbus; the clay marls, at 500–558 feet, at West Asbury Park; the lower water-horizon at Seabright (685–715 feet), and making the third found in wells there, and the correlation of this horizon with that at 465 feet at Atlantic Highlands, Holmdel at 575 feet, Brookdale at 660–715 feet, and with that of 1,083 feet at Asbury Park. The relation of the wells to the tidal waters near them is shown by the oscillations in a shallow well at Pennsville, in Salem county. The same phenomenon has been observed in the rise and fall of the water in the deep wells on the Atlantic Ocean side of the State.

Mr. Woolman has added several well records from the adjacent country to the southwest, in Pennsylvania and Maryland, and also from Norfolk, Virginia. The League Island wells, southern part of Philadelphia, show clays containing fresh-water diatoms mixed with marine forms, as evidence of an old river which deposited the clays in fresh water and commingled with salt water, as might occur to-day in the lower reaches of the Delaware. They are at 25–38 feet and rest upon gravels which are probably of the Pensauken formation. The records of wells in Maryland show that there is a correspondence between the beds passed through in them and the New Jersey wells. This is true at the Centreville well, where marl beds and characteristic fossils were found in the borings. The Norfolk well found a diatomaceous clay at 640 feet, and at 790 an exogyra was struck. These wells at the southwest indicate the extension of the same beds and the same water-horizons through eastern Maryland and into Virginia as in New Jersey.

In the northern part of the State many wells have been bored in the drift of the surface formations and through them into the underlying rocks, but not with the same degree of success as in the southern part. The varying result of these experiments in the more northern Highlands, and in the crystalline-rocks country has not led to the general use of this system of water-supply, and there are few artesian or deep-bored wells. The same general statement may be made about the limestone and slate rocks of the Highlands valleys and of the sandstones of the mountainous ranges. There are few wells bored in them and they do not give encouragement to the deep boring for water. The limestone, with its cavernous features and its irregular water system, or circulation of water, does not offer much hope for large supplies by means of deep wells. The slate belts may be more promising, although uncertain. As is well known, the slate-hill country is famous for its numerous springs and its many brooks, and it is to be expected that borings in the slate will ultimately strike water-horizons and make good wells.

The sandstones offer a more inviting field to the well-borer, as they are in places open and coarse-grained and are traversed by systems of joints and fissures open to the circulation of the subterranean waters. In the sandstone of the Newark system of rocks (or the red sandstone of the Triassic age), there are many wells which yield large volumes of water, particularly in the city of Newark and its vicinity, and at Passaic and Paterson. On Bergen Hill and in the trap-rock, a well at Fort Lee, at 875 feet passed through trap-rock and entered a shale, but without getting a satisfactory flow of water. At the Joseph Dixon Crucible Company's works in Jersey City the boring was made through the sandstone and into the crystalline micaceous rocks underlying the sandstone. It is reasonable to believe that there are open and water-bearing horizons in these sandstones, but our scanty data do not show them. Further exploration in well-borings in the Triassic sandstone country is greatly wanted.

TOPOGRAPHIC WORK.

The topographic work has been continued in charge of Mr. C. C. Vermeule, and Mr. P. D. Staats has been his field assistant. The drawings for photo-lithography have been made by Mr. J. R. Prince, and also some photographs of interesting topographic features have been taken by him.

The field work has included the extension of the revision survey about Elizabeth, Plainfield, Rahway and Perth Amboy, in the northern part of the State, and about Woodbury, Medford and Mount Holly, in the southern part.

At the end of the last field season about three hundred square miles had been covered by this revision survey, including the Jersey City, Newark, Paterson, Hackensack and Camden sheets. The first four of these sheets have been printed; the Camden sheet is nearly ready for the engraver. The field work of the present season includes the Elizabeth, Plainfield, Amboy, Woodbury, Mount Holly and Taunton sheets, and an area of about

400 square miles, making a total of 700 square miles which has been covered by the new topographic survey.

The preparation of these sheets for the engraver will be a part of the office work for the coming winter. The importance of the changes in the highways, railway lines, political divisions, etc., which have taken place in the twelve to twenty-one years since the topographical survey was made, is more and more evident as the work progresses, and indicates the necessity of this revision survey.

The scale of the published maps of the new series is one inch for 2,000 feet, or about two and a half times that of the maps of the old series. The larger scale enables us to make the necessary additions and corrections and an advance in the cartography of the State by more accurate delineation and the addition of important details which could not be shown on the one-inch-scale maps. The reproduction by photo-lithography secures the accuracy of the original drawing made under the direction and watchfulness of the topographer of the Survey in the printed maps.

The sheets of the topographical atlas on the one-inch scale are revised from time to time, as new editions are called for to replace the depleted stock. About all that can be done, however, is to add the new steam railroad lines, the more important changes in the town and county boundaries, and the names of new places. A complete revision of these sheets, so as to bring them up to date in all respects, would be impossible, except that they were re-engraved.

Some work has been done in revisiting the areas covered by the forest surveys in the Highlands and in the deforested districts of the Raritan valley. The preparation of the forest map of the northern part of the State has taken some time. Other work in this division has been, as heretofore, the preparation of illustrations for the Annual Report and the collection of material for the continuation of the study of water-supply from wells which was begun last year.

DRAINAGE.

The general drainage laws provide for the improvement and reclamation of the wet lands of the State, both tidal or salt meadows and wet fresh-water lands. "On the application of at least five owners of separate lots of land, included in any tract of land in this State which is subject to overflow from freshets, or which is usually in a low, marshy, boggy or wet condition," the Board of Managers of the Geological Survey is authorized to make surveys of such tract or tracts and to adopt a system of drainage for the same. The plans and surveys are submitted to the Supreme Court, and commissioners to do the work are appointed by the Court. Under these drainage laws the Pequest meadows, in Warren county, have been improved. The Passaic drainage work, which was begun under the provisions of this act, has been suspended, for want of funds, since 1892. The following extract from our last Annual Report is reprinted, as pertinent to the conditions which are bearing on the work: "The importance of the work in its relations to the lands in the upper Passaic valley, subject to overflow, in the improvement of the quality of the water of the Passaic river at Little Falls, and in the betterment of the sanitary conditions of all this part of the State, calls for immediate attention on the part of not only the landholders and residents of the valley, but of all who are interested in the promotion of the public health and the prosperity of the people of the State. It is not merely a local work of improvement, it bears the approval of a department of the State in its plan, and a State-appointed commission is charged with the execution of the plan. The work must be done, but this long delay is unfortunate in leaving thousands of acres of rich meadows to be wasted yearly by floods, in spreading malarial fevers all through the valley, and in fouling the Passaic river water with an enormous mass of decaying vegetable matter. * * * The State has given all the legislation which has been asked, and the courts have certified to the constitutionality of all the drainage laws which were effective in the case of the Pequest drainage, where conditions were similar to those which prevail in this valley."

RECLAMATION OF THE HACKENSACK AND NEWARK MEADOWS.

Reports on the extent, condition and plan of reclamation ot these meadows were published in the Annual Reports for 1896 and 1897.* The subject was referred to in the last administrative report, and attention was called to the fact that 8,700 acres, or nearly one-third of the total area of 27,000 acres, were within the corporate limits of Newark, Jersey City and Elizabeth, and within 10 miles of New York. The improvement of the 4,000 acres in Newark is proposed, and the legislation for doing the work is adequate and comprehensive. The extension of the city over this tract to the deep water of the Staten Island sound will be made possible by the reclamation work. The subject is presented by Mr. Vermeule in a paper appended to this report. The depreciation of values of real estate near the meadows, and the increase which would follow from the reclamation, are strong arguments for the work of improvement. The sanitary benefits commend it not only to the owners of the lands to be drained, but to the residents of the adjacent upland.

FOREST SURVEYS.

The Geological Survey has been engaged in the investigation of the condition and extent of the forests of the State since 1894. The act of the Legislature, approved May 1st, 1894, provided for the survey of the forested lands of the State, to be made by the State Geologist, under the direction of the Board of Managers of the Geological Survey, and assisted by a competent botanist and expert in forestry. The leading objects of this survey of the wooded lands of the State were to ascertain their extent, character and location, and "the advantages as regards timber-supply, water-supply, scenery and climate of the State, which would accrue from the conservation of existing forests" by the establishment of a State forest reservation, and the preparation of a report which should give "an outline of the policy and legislation of other States and countries for the presevation of forests and their regulation for public ends so far as the same may be applicable to this State."

---

* Annual Report cf State Geologist for 1896, pp. 287-309; and Annual Report of State Geologist for 1897, pp. 297-315.

Reports on the progress of the work and papers on forestry have been published in the annual reports of the Survey.[*]

Mr. Gifford Pinchot (Chief of the Division of Forestry, U. S. Department of Agriculture) surveyed the southern part of the State, and his report on the subject of "Forest Fires and Wood Production in Southern New Jersey" was published as an appendix to the last annual report of the State Geologist. The same report contains an important paper by Mr. C. C. Vermeule, Topographer of the Survey, entitled "The Pine Belt of Southern New Jersey and Water-Supply."

During the last field season Mr. Vermeule had charge of the work of revising the map of the forests in the Highlands and preparing it for publication. He has given some time to the examination of the questions of forests and water-supply and forests and rain-fall, particularly with reference to the water-sheds of the Highlands, from which district the large supplies for all of the cities of the northeastern part of the State must be obtained. The great importance of the subject of water-supply has suggested the preparation of the forest map of the Highlands. The general condition of the forests of the State also has been studied by Mr. Vermeule, and the results have been given in his report, which is incorporated in the Report on Forestry. Some work has been done by Mr. Staats, under the direction of Mr. Vermeule, in ascertaining the changes in the area of woodland in the valley of the Raritan river, in Somerset and Hunterdon counties.

The question of fires in the forest and the methods of protection, particularly in the southern part of the State, have been studied, and Prof. John Gifford, of the New York College of Forestry, at Cornell University, Ithaca, formerly connected with the Survey, has prepared a report on "Silviculture and Forest Protection in Europe and the Relation of European Methods to Conditions in New Jersey." He gives most interesting notes on his observations of the forests in France, Germany, Holland, Belgium and Denmark, and shows the directions in which they are suggestive to the land-owners and managers of woodland in New Jersey, and also some of the points in their management, which are not adapted to conditions as existing here, particularly in the southern part of the State. On the question of forest protection he has reached the conclusion that a system of fire-lanes, or State roads, which may answer the same ends in affording a fighting line or a barrier to the movement of fires, is the most effective and at the same time practicable. He cites the new State road from Camden to Atlantic City as being in effect a fire-lane, across which no forest fires have spread. His report will appear in full in the Report on Forestry.

---

[*] *Annual Report, State Geologist for 1894, pp. 223-286* —Report on Forestry in the Northern Part of the State, by C. C. Vermeule, and Preliminary Report on the Forest Conditions of South Jersey, by John Gifford.

Annual Report, State Geologist for 1895, pp. 97-188.—Report on Forestry in Northern New Jersey, by C. C. Vermeule; Report on Forest Fires for season of 1895, by John Gifford; and Notes on the Forests of New Jersey, by Gifford Pinchot.

Annual Report, State Geologist for 1896, pp. 337-365.—Notes Collected during a Visit to the Forests of Holland, Germany, Switzerland and France, by John Gifford.

Annual Report, State Geologist for 1898, pp. 183-193, and Appendix, pp. 1-102.—The Pine Belt of Southern New Jersey and Water-Supply, by C. C. Vermeule; and A Study of Forest Fires and Wood Production, by Gifford Pinchot.

The legislation of the year on forest protection has consisted of three sections in the general act concerning townships. These sections permit of the raising of money by each township for the necessary expenses attending the work of subduing fires in the woods, the appointment of a fire warden, and the preparation of maps showing the forest lands and the lines of railroad and wagon-roads. The Geological Survey is prepared to furnish maps showing these lines and the forest areas in all the townships of the State. It now remains for the local authorities to put the act in force, in so far as it relates to forest protection, by making an appropriation of money for the work, and by appointing fire wardens. The following extract from this act is here inserted :

CHAPTER 169.

An Act concerning townships [Revision of one thousand eight hundred and ninety-nine].

Approved March 24th, 1899.

BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

* * * * * * * * *

FOREST FIRES.

54. In any township where any sum of money shall be raised to defray the expenses of fighting and extinguishing forest fires, it shall be the duty of the township committee, at its next meeting after such sum shall have been ordered raised, to appoint a suitable person, being a resident of said township, to act as fire marshal thereof, and at the same time to determine the amount of compensation per diem to be paid such fire marshal when in the active performance of his duties; upon notice from the person so appointed of the acceptance of the said office the said township committee shall immediately issue to him a certificate of his appointment under their hands; after receiving his certificate of appointment he shall have the power to designate a proper person to act as his deputy in case of his absence or disability from any cause, and the said deputy shall, while engaged in the active duties of the said office, receive the same compensation per diem as his chief.

55. It shall be the duty of said marshal, on being apprised of the existence of any forest fire, either in his own township or in any adjoining township, by which the safety of any property in his own township may be imperiled, to assume absolute direction and control of all operations to be undertaken within the bounds of his own township for the extinguishing or prevention of the spread thereof; he shall have power during the continuance of such fire to appoint as many persons to act as aids in carrying out his instructions as he may deem necessary, and all persons present who may be actively engaged in subduing such fire shall act solely according to his orders and those of his

authorized aids; he shall keep an account of the persons so appointed by him as aids, and of all other persons actively engaged in fighting such fires, together with the time during which they are employed, and in a reasonable time after such fire shall have been extinguished he shall report said account to the township committee, who shall have power to make reasonable compensation for such services out of any moneys that may have been appropriated therefor; if in the judgment of the said marshal a forest fire in an adjoining township shall imperil the safety of any property in his own township, he may, with his aids appointed as aforesaid, and with such other persons as he may employ, render such assistance as he may think necessary for the extinguishment and prevention of the spread of said fire, and any assistance given him in such service shall be reported to, and paid for by, the township committee of his own township in like manner as aforesaid.

56. The township committee may cause to be made an accurate map or maps of such portions of the forest lands of their township as may be subject to damage by fires, with such railroads and public and private roads delineated thereon as they may deem necessary, and shall cause to be made whatever surveys and measurements are necessary for the proper completion of said maps; one copy thereof shall be filed with the township clerk, and so many copies of the same shall be furnished to the fire marshal as the said committee shall deem advisable.

The Geological Survey has indicated in the Report on Forestry and on its forest maps the location and extent of the several large forested districts of the State and their relations to the available water-supply for the use of our cities and towns, and the advantages accruing from the establishment of State forest reservations have been given in this report. The forests in the Highlands are to some extent locally protected by individual owners, who appreciate their value as features of the scenery, as private parks and game preserves, and in some cases for the timber which is produced. The management is in places conservative and in some degree silvicultural. The crop of timber is cut so as to be profitable. That the management generally might be made to follow the methods of scientific silviculture or timber-culture and be more profitable than it is now is probably correct, but in the absence of trained foresters and under the existing conditions of high taxes and the necessity for income within short time limits, changes of this kind are hardly possible at once. What is needed is a forest experiment station or reservation, which may be the property of the State or an educational institution, where the practicable methods of tree planting or silviculture and of timber-cutting and marketing can be studied by land-owners and managers.

The protection of the timbered hillsides and mountains of the Highlands is necessary to the prevention of too rapid discharge of floods and the transportation of earthy matters from the bared ground. Ultimately a State forest reservation may be desirable as a means of protecting these water-sheds.

The Kittatinny mountain is another woodland belt which may become a desirable reservation in order to prevent forest fires.

The Palisades range is notable for its old timber and the large tracts of woodland, on the Hudson river and so near New York city. Its situation makes it valuable far in excess of the timber as a crop, and the question of preservation is in the adaptation to sites for suburban parks or recreation grounds.

The remaining large area of forest is the pine belt of the southeastern part of the State. It has been over-run by fires and the valuable old timber has been nearly all cut, leaving broad stretches of brush-land and fire-scarred plains, and the value of the whole as timber-producing is so little that a forest reservation for the wood alone would be a source of expense. The water-supply in it is its most important asset.

THE MINING INDUSTRY.

The report on the iron mines of the State has been prepared by Mr. George E. Jenkins. He visited the several mining districts and collected data about the mines—their extent of workings, depth, equipment, nature of ore, statistics of output and names of owner or lessee. This information is given in the report. The statistics of iron ore, shipped from stations in New Jersey over the several railway lines, are given on pages .

The remarkable advance in the price of iron ore and the increasing demand have stimulated the working of the mines which were in operation last year and during the period of depression in the business, and their output has been larger than it was last year. Many of the mines which had been closed on account of low prices and slack demand for ore have been re-opened. There have been some important changes in management and some new companies have engaged in the business of mining. The inquiry for new localities also has been noted, and many letters have been received at the office of the Survey, asking information about mines and new ore localities. At the end of the year nearly all of the large and historic mines were either being worked or were being re-opened with a view to early production.

The question of concentrating lean ores on a large scale has received close attention, and the concentrating plant at Hibernia has been at work nearly the whole year on the lean refuse from the Hibernia *vein* and on Beach Glen mine ore. The Edison works also have been at work a part of the time.

The total shipments for the year amount to 300,757 tons, an excess of 25,379 tons above the aggregate production for 1898.

The revival in the iron trade and the active demand for iron ore make the report of value and warrant the belief that the iron-mining industry of New Jersey has entered a period of prosperity comparable to any in its history, marked by a substantial character and lacking some of the elements of excessive stimulation which were so evident in 1879, after the depression of 1873–79. The excellence of the ores, the large size of the ore-shoots, the nearness of the mines to the great manufacturing industrial centers and to the great markets, and the location, on or near the great lines of transportation, are conditions favoring the steady continuance of this activity in iron mining.

The operations of the year have been all in the magnetic iron ore and no attempt has been made to re-open the hematite mines.

For descriptive notes on the iron mines of the State reference may be given to the Annual Reports for the year 1890, and succeeding years, as also to the "Geology of New Jersey," 1868, and the earlier annuals.

COPPER MINING.

A short report on some of the copper mines and copper ores of the State has been prepared by Mr. Kümmel. The re-opening of the old Schuyler mine, near Arlington, in Essex county, marks a noteworthy epoch in the history of the oldest copper mine of the State of which there is accurate historical record.*

CHEMICAL WORK.

The chemical investigations and analyses have been made by Prof. William S. Myers, of New Brunswick. They have been examinations of minerals, rocks and ores in order to the determination of the species and, in a few cases, to ascertain the metallic percentages and the value of the specimens for use in the arts. In addition to the regular work of chemical analyses, Professor Myers has made a beginning in the investigation of the amount of chlorine in the natural waters of the State. Samples of water have been collected by the members of the Survey staff, from artesian wells in the southern part of the State, from springs, lakes and rivers, and from the sources of supply of all the large cities of the State. The total solid matters and the amount of chlorine have been determined in these samples, representing the waters of the natural sources of supply. The results are given in the report of Professor Myers. They indicate the decrease in the chlorine content going from the ocean northwest and west, as would be anticipated, as the sources are further from the salt waters of the ocean and the tidal bays and sounds of the coastal part of the State. It is proposed to have a map made to show the amount of the chlorine which marks the natural waters in the several districts of the State.

The usefulness of a chlorine map will be evident in the comparison which it will enable the chemist to make between the normal percentage and that found in any given sample and to decide at once as to the purity of the water. The excess of chlorine will indicate the probable pollution by sewage and suggest further tests. Such a map will be a guide of service to the water-analyst, and afford a safe criterion for judgment as to the purity and healthfulness of the waters which are used for domestic purposes. Massachusetts has a map of this kind and New Jersey has a large part of the data ready for constructing such a map. Another season's work will give enough additional information to allow of its preparation and publication.

---

* The earliest mining for copper ore in the State was probably done by the Dutch official authorities in the valley of the Delaware river and in Pahaquarry. The working there was about the middle of the seventeenth century and the mines were connected by the "mines road," with the settlements on the Hudson river at Esopus (now Kingston)

GEOLOGICAL ROOMS.

The collections of minerals, rocks, ores, clays, marls and other economic products which occur naturally in the State are arranged in the museum-room in the rear extension building of the State House, and adjacent to the office of the Survey. They are in wall-cases and in table-cases, and, in part, in drawers in drawer-cases. Additions are made by members of the Survey staff collecting in the field in course of geological work, and by the gifts of friends. The mineralogical collection is in the care of Professor A. H. Chester, of New Brunswick, and it attracts the attention of all the visitors to the Museum. Although representative of the species which are found in the State, it lacks the fullness of localities which is desirable in a State collection. All the localities should be represented by specimens, so as to make a complete showing of the occurrence of minerals. Many of the specimens in the exhibition-cases are poor, and unworthy a place in such a collection, and the replacement by good specimens is necessary to a creditable exhibition of the beautiful minerals of New Jersey.

The paleontological collections are shown in part only, and the type specimens of the greensand marl formations are packed in boxes in the basement, for want of room for their proper exhibition.

The collections of the industrial arts are shown in part only because of want of room. An increase in the number of these economic art products would be easy were there space in which to exhibit them. The value of these collections of manufacturing industry by the side of the raw products and materials occurring naturally in the State needs no argument here.

Arrangements for a new and larger collection of the woods of the State have been made, and those which are native in the southern part have been promised by a friend of the Survey and botanist, Mr. Benjamin Heritage, of Mickleton, Gloucester county.

Several maps of the State have been mounted and hung on the walls near the door. They make an interesting series, historically.

The number of visitors to the museum-room is increasing each year, and the earnest efforts of the enthusiastic Curator of the State Museum have contributed greatly to the general interest in the exhibition and in the appreciation of the collections. Nearly all of the visitors to the State capital visit the museum. The information which is given in this way is, to some extent, educational, but much more could be given, and in an instructive as well as pleasing manner, if there was more space for the proper exhibition of the material now in the collections and additional synoptic and general collections illustrating the general principles of science and art as well as the more special collections of the State. Additional room is proposed in the projected extension of this part of the State House.

LIBRARY.

The books of the library of the Survey are in part arranged in two small wall-cases in the office. Many of the bound volumes and all of the unbound books and pamphlets are stored in boxes in the basement of the State House. The additions are mainly through the exchange of the publications of the Survey with scientific societies and other State and national geological surveys. A few hand-books and works of general reference are bought as needed. The increase during the year has been much larger than in any year of the Survey's history, and has suggested the necessity of a card catalogue, which is being prepared by Mr. Kümmel. On account of the incomplete state of many of the series of reports, in some cases represented by a single volume only, there is urgent necessity for effort to fill these large gaps, and hence additions by exchanges and donations of books are greatly desired. The proposed alteration of the State House and more room will allow of the location of the library in the geological rooms convenient for use.

PUBLICATIONS.

The Annual Report for 1898 and four topographic maps, viz., Newark, Jersey City, Hackensack and Paterson sheets, are the publications of the year.

The work of distributing the publications of the Survey increases from year to year and is recognized as important and valuable in putting the results of the studies and surveys of the workers promptly in the hands of the people of the State, and in libraries and educational institutions generally throughout the United States. The public schools of the State are recipients of the volumes of the series of Reports on the Topography, Geology and Natural History of the State. During the year the distribution of Volume IV, on the Physical Geography of the State, has been completed. The relief map of New Jersey, on the scale of one inch to three miles, which accompanies this volume, has been sent, mounted on rollers, to all the schools. The work has been done by the Department of Public Instruction and by Mr. Herbert N. Morse, of that department. The educational value of the map and of the "Physical Geography" of the State is recognized by the best teachers of geography and is demonstrated by the demand for additional copies in order to have them not only in all the schools of the State, but in several school-rooms in each high-school in the larger towns and cities.

The distribution of the topographical atlas of the State, in sheets, backed and with inset eyelets for hanging on a wall, has been in progress, and many sets of these maps have been sent to the public schools on the order of the superintendent of public instruction. The Geological Survey is the custodian of the stock. A large part of the edition has been distributed, and the purpose of the legislative act has been fulfilled in placing them in the schools throughout the State. The remaining copies will answer the demand for new copies to replace those worn out or out of repair, or which may have been lost.

APPENDIX.

Report on the Surface Formations.

By ROLLIN D. SALISBURY.

The survey of the surface formations has now been extended over the whole State, and the only further field work which will be necessary will be a review of the work in certain portions of the State in advance of the publication of the maps. The study of these formations has been carried to a considerable degree of detail, except in the sandy, pine-covered areas of the southern part of the State. In this unbroken belt the lack of detail was deemed advisable, both because of the lesser importance of the work in this region, and because data for detailed work could not be obtained without great, and what was regarded as unwarranted, expense.

Not only has the work been done in much detail, but it has been done for the most part without established standards, for no such detailed work on the surface formations has been undertaken by any other State survey. The geographic position of New Jersey has perhaps rendered work of this sort especially important, for within its area lies the junction of the Coastal plain with the Piedmont plateau, and the junction of the glaciated area with the unglaciated. This position makes it in some ways a critical and important area in the study of surface formations, for nowhere in geology has there been less satisfactory correlation than in the surface formations of the north and the south, and of the uplands and lowlands.

Many of the results of the survey have been published from time to time in the Annual Reports from 1891 to 1898. It now remains to publish the unified results. These publications will take the form both of maps and of descriptive and interpretative matter. In the publication of the maps it is thought best not to use the old topographic sheets, which overlap to such an extent as to nearly cover the area of the State twice, but to use a new base of smaller maps which do not overlap. A very considerable saving in the expense of publication will thus be effected, besides providing maps of more convenient size.

It is very desirable that, with the maps showing the surface geology, maps of the sub-surface geology should be issued, so that the relations of the surface and under-geology shall be made clear. Before these latter maps can be issued, some further field work will need to be done, but a good beginning has already been made. The necessary work on the Triassic system has already been done by Dr. Kümmel; work on the Paleozoic systems has been begun by Dr. Kümmel and Mr. Weller, and on the younger systems by Mr. Knapp. The work on these formations should be prosecuted as rapidly as practicable. When it is completed, a new and complete map of the geology of the State will replace the old preliminary map which was made before the topographic survey of the State had given an accurate base for detailed work. The simultaneous publication of these two sets of geological maps will be of great value to the State and to geology in general.

The publication of these maps should be begun as soon as possible and pushed as rapidly as conditions permit, but before the maps for any given area are issued, the topographic base should be revised. This revision, already in progress, is especially necessary in two classes of areas, namely, those where the surface has been greatly changed by culture since the publication of the original topographic maps, and those where the outline of the land has been notably altered by the action of waves and currents, as along the coast from Sandy Hook to Cape May.

The text on the surface geology of the State will appear in two volumes, one on the glaciated area of the north, and one on the area south of the glacial drift. These reports may precede the publication of the full series of maps, but the early sheets of the latter should accompany the reports. It will be the purpose of these reports to set forth the history of the surface of the State in such a manner that it will be intelligible to those who have had no technical education in geology.

Report on Reclamation of Hackensack and Newark Meadows.

By C. C. VERMEULE.

There has been no falling-off of public interest in this projected improvement. The demand for the reports treating of the subject has continued and there is no doubt that they have attained their object by bringing prominently before the people the need of some action, and by concentrating upon the problem the thoughts of many capable minds. The city of Newark has taken up the matter in a way which seems practical and promising of some tangible results. An act of the Legislature was passed last winter which enabled the city to proceed to reclaim the 4,000 acres of tide-marsh within her limits and assess the cost upon the land drained in much the same manner as is done in building sewers and in other municipal improvements. Proceeding under this act the Board of Street and Water Commissioners advertised for plans and proposals, and at the same time the Board of Trade, which has actively promoted such improvement for several years, offered prizes for the best plans which should be submitted. In July several plans were offered in response to the advertisement. The range of prices was large, varying with the plan, but it was evident that a practical plan, which would render the marsh suitable for city occupation, could be carried out at a contract cost not exceeding $300 per acre, an amount which, when compared with the selling price of city lots in Newark, is very small. The plans were first referred to a committee appointed by the Board of Trade and Board of Street and Water Commissioners for a report upon the merits of the plans. This committee has not yet reported. It will report to the Board of Trade and the whole matter will then be referred back to the Board of Street and Water Commissioners for further action. If a contract is awarded the work will proceed in the spring.

There is a wide range in the character and cost of the drainage work, according to the uses to which the land is to be put. In the report for 1897 it was estimated that the drainage of the marshes to such an extent as would render them sanitary and adapt them for agricultural purposes—keeping the water-level some three feet below the level of the land—would not exceed $2,500,000 for the entire 27,000 acres, including all expenses of every kind. This is undoubtedly a liberal estimate, and it amounts to $93 per acre. Leaving out cost of land and administrative expenses, the cost, including pumping-plant, was given at $50.75 per acre. This is but one-sixth the cost of drainage for city purposes as ascertained in the case of Newark. The reason for this is found in the more exacting requirements, mainly in the larger quantity of water to be cared for. If the use of the marsh is mainly agricultural, it will continue to absorb water in case of sudden heavy storms, so that the maximum run-off to be taken care of in the pumping-plants will be at a moderate rate. In the report for 1896, page 297, it was estimated that this would in no case exceed 33,000 gallons per acre in 24 hours, or 1,375 gallons hourly, but in the case of Newark the specifications required that the water should be maintained in all parts of the marsh at least six feet below the land surface, and that the pumping-plants and ditches should have a capacity to discharge 900 cubic feet, or 6,750 gallons, per acre hourly. This larger discharge was necessary because, when all the water should be confined to the ditches and the whole area carefully drained, the streets paved and houses built, the discharge of water would be much more sudden and violent. Then, too, there was a large inflow to the marshes from the upland portion of the city. These requirements, while they were all proper and necessary in that case, made deeper and wider ditches necessary, and called for a pumping-plant, for the 4,000 acres of marsh, having an aggregate capacity of 47,700,000 gallons hourly on 10 feet lift, and 3,200 horse-power will be required to operate it.

The accomplishment of this work will enable Newark to occupy a space now needed for her proper growth and development. The southernmost water-front of the city is now only one mile distant from a channel having a depth of 24 feet out to the ocean. When the meadows have been improved so that the city can reach and occupy this water-front, it will be a simple matter to hàve this channel extended up to the Newark and New York railroad bridge, so that vessels of 22 feet draft can come up to the wharves at all tides. At present there is only about 10 feet of depth at low tide up to the wharves on the Passaic. It is believed that the opportunity to obtain more space and cheaper land on the improved meadows—with better shipping facilities—would induce many of the factories to withdraw from the residential portions of the city, and that the improved land would become the industrial center, leaving the higher ground west for residence. The appearance and sanitary conditions of the city will be greatly improved if such a change is effected, and there can be no reasonable doubt that the direct gain in taxable property, and the indirect advantages in ridding the city of mosquitoes, improving its sanitary condition, making it accessible to ocean steamships and rendering it more attractive in many respects as a place of residence, would be worth several times the whole cost of the improvement.

In many other cases it would not be necessary or desirable to spend on the first improvement over $100 per acre. Less than this expenditure will drain the land and put it in condition for agriculture or grazing. The moment this is done its value will be greatly enhanced. Drained marsh-lands sell in Nova Scotia for from $150 to $200 per acre for agricultural purposes alone, and in some cases as high as $400, and this is at points where the neighboring improved upland is worth only $50 per acre. The diked meadows of Salem and Cumberland counties, in this State, have always been worth several times as much as the improved upland. As much as 55 bushels of wheat per acre and heavy crops of hay are raised on them. A moderate amount of drained tide-marsh attached to a farm in that vicinity greatly enhances the value of the farm.

Now, bearing in mind that much of the outlying lands of the Hackensack marshes, that is, the lands not immediately adjacent to Newark, Elizabeth or Jersey City, can be bought for from $25 to $100 per acre, that it lies within twenty-five minutes of Broadway, New York, and still nearer Jersey City and Newark, that consequently it must have, even for agricultural purposes, a greater value than Nova Scotia or South Jersey marsh land, and that in addition to this value it will have a large prospective value for other purposes immediately that it is seen to be dry, healthful and attractive, it seems impossible that it will be worth less than $400 or $500 per acre after, say, about $50 per acre has been spent in dyking and draining it. Therefore, if a private corporation can secure a sufficiently large area to begin operations, and can drain it and put a small portion under cultivation as a demonstration of the capabilities of the soil, the rest could be promptly leased for enough to give a fair return on the investment, and the appreciation in the value of the land in the course of a few years will undoubtedly make the venture very profitable.

If Newark will carry the proposed improvement through to a successful completion, there is little doubt that Elizabeth and Jersey City will find a way to follow her example. This will dispose of the marshes south of Snake Hill. Then if private corporations will take up the improvement of the remainder on the lines suggested above, the whole marsh will be wiped out and the surrounding communities will reap a very great advantage. This is one way in which the improvement may possibly be effected. Another way, and one which would undoubtedly insure a more comprehensive and advantageous improvement in the end, would be the creation of a drainage commission on the lines laid down in the report for 1897. This plan would remove the speculative features and would give stability to, and insure good sanitary and commercial results from, the improvement. Nevertheless, the present trend appears to be in the direction of a municipal and partly a private undertaking, the extent of each enterprise being from 2,000 to 4,000 acres.

We have made some inquiry as to land values on the upland immediately adjacent to the meadows in Hudson and Bergen counties. In Jersey City and West Hoboken a few blocks back from the meadow edge, city lots 25 by 100 feet are worth from $500 to 1,200 each, while close to the meadows they fall to from $100 to $200. There is practically no sale for lots near the meadows for residence purposes. At Rutherford lots are quoted at about the same rates, $1,000, a few blocks back and

$100 near the meadows. At Arlington it is said to be almost impossible to sell lots near the meadow edge while there is a ready sale at good prices up on the ridge. It is everywhere apparent that the meadows seriously injure the immediately adjacent upland property, which is only available for cheap, undesirable improvements. Yet even if we take the low prices of these depreciated upland lots, say $100 per lot, it amounts to $1,200 per acre, and much of the meadow land, especially that near the railroad lines and along the water-front, would be worth much more than this when drained.

We have urged the improvement of these marshes, mainly as a sanitary measure, and to mitigate the mosquito pest. Recent research identifies the mosquito so closely with the spread of malaria that its suppression must be regarded not merely as contributing to the comfort of the neighboring population, but as a sanitary measure as well. The sanitary advantages of the improvement, and the increase in value of all upland real estate east of Orange mountain are of themselves quite a sufficient return for the entire cost of $2,500,000 necessary to put these marshes in a condition suitable for agricultural, horticultural or grazing purposes. While it seems clear that the improvement would yield a sufficient return from the enhanced value of the marsh land, if private capital is not willing to undertake it then it should be accomplished as a public enterprise, on the lines suggested in the report for 1897. The advantages of that plan are that it properly recognizes and respects the rights of the owners of the marsh land by putting a reasonable share of the burden on the shoulders of the surrounding communities, which will reap so large a share of advantage, and it provides for a single and comprehensive control with a minimum of interference with existing municipal governments.

PART I.

Report on Paleozoic Formations

BY

STUART WELLER.

A Preliminary Report on the Stratigraphic Paleontology of Walpack Ridge, in Sussex County, New Jersey.

By STUART WELLER.

CONTENTS.

Introduction.
Formations of the Silurian System.
  Poxino Island Shale.
  Bossardville Limestone.
  Decker Ferry Formation.
    Chonetes jerseyensis zone.
    Ptylodictya platyphylla zone.
    Rhynchonella lamellata zone.
    Correlation of the faunas of the Decker Ferry formation.
    Correlation of the Bossardville limestone and the Poxino Island shale.
  Rondout Water-lime Formation.
Formations of the Devonian System.
  Manlius limestone.
    Spirifer vanuxemi zone.
  Coeymans limestone.
    Gypidula galeata zone.
  New Scotland beds.
    Spirifer perlamellosus zone.
    Spirifer macropleurus zone.
    Spirifer cyclopterus zone.
    Vertical range of species in the New Scotland beds.
  Stormville Sandstone.
  Becraft Limestone.
    Dalmanites dentatus zone.
  Oriskany beds.
    Spirifer arrectus zone.
  Esopus grit.
  Onondaga limestone.

INTRODUCTION

The paleozoic rocks of New Jersey fall naturally into three areas. The first of these is situated in the region of Green Pond and Bearfort mountains; the second is the Kittatinny valley, lying between the pre-cambrian highlands on the southeast and the Kittatinny mountain on the northwest, and including some isolated areas of paleozoic rocks within the crystalline area; the third area is the Delaware valley, lying between the crest of the Kittatinny mountain and the Delaware river.

The third area consists of two parallel valleys separated by the Walpack ridge. To the southeast of this ridge, between it and the Kittatinny mountain, is a valley drained in its southern portion by the Flat brook and in its northern portion by the Clove brook. This is essentially a continuous valley whose central portion has been filled with glacial drift, and it will be spoken of hereafter as the Walpack valley throughout its entire length. Along the northwestern foot of the Walpack ridge flows the Delaware river. At the mouth of Flat brook the Delaware makes a great sigmoidal bend known as the Walpack bend, cutting through the Walpack ridge, so that the more southwesterly extension of the ridge is in the State of Pennsylvania. At the north the Clove brook cuts through the ridge near the State line and empties into the Neversink river at Tri-States, New York, near the point where the latter stream joins the Delaware.

The unfossiliferous Medina sandstone covers the whole northwestern slope of the Kittatinny mountain, extending approximately to the middle or even beyond the middle of the Walpack valley, so that the fossiliferous strata of the region are restricted to the Walpack ridge. The strata of this ridge dip, with some local exceptions, more or less steeply to the northwest, so that in passing from the Walpack valley to the Delaware river, younger and younger strata are encountered. The northwestern slope of the ridge usually approximates more or less closely to the dip of the strata, so that the complete section is usually exhibited in passing from the Walpack valley to the crest of the ridge or a little beyond the crest. It is the succession of the strata in this section, with their included fossil faunas, which will be described in the present report.

Rock exposures are frequent throughout the entire length of the Walpack ridge, and many of the strata are highly fossiliferous. The best section for study, however, is to be found about two miles south of the New York State line, on the farms of John Bigart and Sanford Nearpass, in a quarry known as the old Wm. Nearpass quarry and in the ridges lying beyond. The Nearpass section will be used as a basis for the following descriptions of the faunas, because the actual succession can be worked out in greater detail at this point than anywhere else in the Walpack ridge, although in some cases particular beds are better exposed elsewhere. The continuous rock exposure in the Nearpass quarry bluff is about 150 feet, but between the top of this exposure and the main crest of the ridge there are some 700 feet of strata which are not continuously exposed, but whose hard layers make persistent outcrops.

The formations of the Walpack ridge belong to the Silurian and Devonian systems, and they will be described in succession from the base upward. In general, the formations in New Jersey are continuations, either of those in New York or of those in Pennsylvania, and have been given names by the members of the geological surveys of these two States. For most of the Silurian formations the names used by the Pennsylvania geologists are best adapted to the New Jersey section, while for the Devonian formations the New York names are applicable.*

Formations of the Silurian System.

POXINO ISLAND SHALE.

The lowest formation exposed in the Walpack ridge is a buff or greenish calcareous shale, irregularly bedded, in layers one inch or less in thickness. In the bottom of the Nearpass section about one foot of this rock is exposed in an excavation, which has been made in the talus slope at the foot of the bluff. South of Hainesville is another exposure, where a quantity of the material has been excavated for road-making purposes. There are also other exposures south of Walpack Center, but nowhere have fossils of any description been observed.

This formation was first described by I. C. White in his report on Pike and Monroe counties, Pennsylvania,* but he did not observe any outcrops of the formation in New Jersey. These New Jersey exposures, however, have been traced southward by Dr. Kümmel to the type exposure of the formation in Pennsylvania opposite the Poxino island. The base of the formation has not been observed in New Jersey, but in Pennsylvania it is described by White as resting upon a thin limestone formation which in turn rests upon the red Medina sandstone. Only a small part of the entire thickness of the formation is exposed anywhere in New Jersey, but it is described as being at least 200 feet thick in Pennsylvania.

BOSSARDVILLE LIMESTONE.

Lying above the Poxino Island shales is a fine-grained, compact, bluish, banded limestone. It is exposed in the Nearpass section in the excavation already mentioned, where its entire thickness is 12 feet 4 inches. From this point south to Peter's Valley but few outcrops are to be seen, but between Peter's Valley and Flatbrookville there are many excellent exposures. The thickness of the formation is greatly increased to the south, and although no exact measurements could be made, it is at least 100 feet thick below Walpack Center. This formation is unquestionably a northern extension of the limestone designated as the Bossardville limestone by White† in Pennsylvania. It is also the formation which was called the "Ribbon Limestone" by Prof. Cook,‡ and which was erroneously correlated by him with the "Ribbon Limestone" at Rondout, New York, which is the Manlius or "Tentaculite" limestone lying above the water-lime formation. This correlation of the Bossardville limestone was also adopted by White in his Pennsylvania report.

As a matter of fact, the age of the Bossardville limestone is very much greater than that of the Manlius limestone at Rondout, although the two formations are somewhat similar in lithologic characters. The Bossardville limestone itself is entirely barren of fossils, but it is followed by a series of beds which are highly fossiliferous, containing fossils of well-defined Niagaran* age. By reason of this error in correlation, this formation, with the subjacent Poxino Island shale, has in former reports usually been included in the Helderbergian series, and the softer, upper portion of the Medina sandstone has been designated in the Pennsylvania reports as the Clinton red shale,† with apparently no further reason than the belief that the Clinton beds must be represented by the beds immediately beneath the supposed Lower Helderberg.

---

* 2d Geol. Surv. Penn., Rep G6, p. 145

† 2d Geol. Surv. Penn., Rep. G6, p. 141.

‡ Geol. of N. J., p 156 (1868).

DECKER FERRY FORMATION.

In his report on Pike and Monroe counties, Pennsylvania, White‡ has described three formations succeeding the Bossardville limestone, which he designates by the name Decker Ferry, from the ferry of this name below Flatbrookville—the Decker Ferry shale, the Decker Ferry sandstone, and the Decker Ferry limestone. The first two of these formations are closely allied, the so-called shale being an alternation of thin sandstone beds with thin beds which are more calcareous, rather than a true shale. These two formations of White will here be included in a single division and will be called the Decker Ferry formation. The Decker Ferry limestone of White is quite distinct, both faunally and lithologically, from the Decker Ferry formation here recognized.

At Flatbrookville and north to Peter's Valley, this entire formation could legitimately be called a sandstone, but with many thin calcareous bands, especially in the lower portion; but north of Peter's Valley the formation rapidly becomes more and more calcareous until in the Nearpass section the whole formation is for the most part limestone, with some thin bands of more or less fissile greenish shale. Only about two feet at the very base of the formation, immediately on top of the Bossardville limestone, show any indication of being arenaceous, and even this is an earthy limestone with a small percentage of siliceous matter, rather than a true sandstone.

---

*This term is here used in the sense adopted by Clark and Schuchert in Science, N. S., vol. X, No. 259, pp 874-878, for the period during which the following formations were being deposited in western New York, the Clinton beds, the Rochester shale, the Lockport limestone and the Guelph dolomite. In New Jersey, however, the period is represented by a different set of formations.

†2d Geol. Surv. Penn., Rep. G6, p. 147.

‡2d Geol. Surv. Penn., Rep. G6, pp. 137-141.

In New Jersey the Decker Ferry formation is usually fossiliferous, sometimes highly so, but in many instances the fossils are poorly preserved. At Flatbrookville, at the very base of the formation, there are a few inches of thin alternating beds of fine-grained limestone resembling the Bossardville in its lithologic characters, and of coarser, more crystalline limestone like that above. These beds are individually but a fraction of an inch in thickness, but there is a conspicuous alternation of faunas represented in them. The fine grained layers are often crowded with a rather large, smooth *Leperditia* and contain nothing else, while the more crystalline layers contain the same fossils that occur in the overlying beds.

In the Nearpass section three somewhat distinct life zones may be recognized in this formation, although some species range through its entire thickness. These zones can also be traced to the south, though as yet only the lowest one has been definitely recognized throughout the entire length of the Walpack ridge in New Jersey. These three zones will be named from their more conspicuous species, the *Chonetes jerseyensis* zone, the *Ptilodictya platyphylla* zone and the *Rhynchonella lamellata* zone.

Chonetes jerseyensis zone.* In the Nearpass section several distinct beds contain the species of this zone, and they will be described in order from the base up.

I. Highly fossiliferous, earthy, somewhat arenaceous limestone resting upon the Bossardville limestone, 2 feet in thickness. The following species of fossils have been identified:

1. *Zaphrentis* sp. undet.
2. *Monotrypa* cf. *M. undulata* Nich.
3. *Pholidops* sp.
4. *Stropheodonta bipartita* (Hall).
5. *Orthothetes* n. sp.
6. *Dalmanella elegantula* (Dal.).

---

* Although this species cannot be illustrated in this place it has been thought best to apply a name to it, because it is so peculiar and so characteristic of this faunal zone. The species will be illustrated in next year's report.

Chonetes jerseyensis, n. sp. Shell large, often attaining a width of more than 20 mm. Surface marked by coarse, sharply angular plications which increase in numbers towards the margin of the shell. On the brachial valve the plications become coarser toward the hinge-line and are peculiarly curved, the convex side of the curve being toward the hinge-line. The margin of the cardinal area of the pedicle valve bears four or five or more oblique spines on each side of the beak.

7. *Chonetes jerseyensis* Weller, n. sp.
8. *Camarotoechia neglecta* (Hall).
9. *Rhynchonella* sp. undet.
10. *Atrypa reticularis* (Linn.).
11. *Reticularia bicostata* (Van.).
12. *Pterinea* sp. undet.
13. *Mytilarca mytiliformis* (Hall).
14. Pelecypods (several undet. sp.).
15. *Straparollus* sp. undet.
16. *Loxonema ?* sp. undet.
17. *Orthoceras* sp. undet.
18. Ostracodes (several undet. sp.).
19. *Dalmanites* n. sp. ?
20. *Phacops trisulcatus* Hall.

II. Hard blue crystalline limestone with many fossils, but which are not so well preserved as those in the subjacent bed. 14 feet 2 inches.

1. *Favosites* sp. undet.
2. *Monotrypa* cf. *M. undulata* Nich.
3. *Stropheodonta bipartita* (Hall).
4. *Orthothetes* n. sp.
5. *Dalmanella elegantula* (Dal.).
6. *Chonetes jerseyensis* Weller, n. sp.
7. *Camarotoechia neglecta* (Hall).
8. *Rhynchonella* sp. undet.
9. *Atrypa reticularis* (Linn.).
10. *Reticularia bicostata* (Van.).
11. *Cyrtina* sp. undet.
12. *Lichenalia ?* sp. undet.
13. *Ptilodictya* sp. undet.
14. *Platyostoma* sp. undet.

III. Fissile shale with limestone bands. No fossils collected. 6 feet 9 inches.

IV. Hard blue crystalline limestone with lithologic characters similar to No. II. Fossils poorly preserved. 8 inches.

V. Shale band. No fossils. 2 inches.

VI. Hard blue crystalline limestone similar to Nos. II and III. 2 inches.

1. *Stropheodonta bipartita* (Hall).
2. *Chonetes jerseyensis* Weller, n. sp.
3. *Camarotœchia neglecta* (Hall).
4. Ostracodes sp. undet.

VII. Shale band, no fossils. 2 inches.

These seven beds in the Nearpass quarry section contain the fauna of *Chonetes jerseyensis.* On the next farm south of that upon which the old Nearpass quarry is located, these lower Decker Ferry beds are exposed and the following species have been identified from a bed which is probably a continuation of the lowest bed described above, although it was not observed resting directly upon the Bossardville limestone:

1. *Favosites* sp. undet.
2. *Monotrypa* cf. *M. undulata* Nich.
3. *Stropheodonta bipartita* (Hall).
4. *Orthothetes* n. sp.
5. *Dalmanella elegantula* (Dal.).
6. *Chonetes jerseyensis* Weller n. sp.
7. *Camarotoechia neglecta* (Hall).
8. *Rhynchonella* sp. undet.
9. *Atrypa reticularis* (Linn.).
10. *Reticularia bicostata* (Van.).
11. *Leptodesma ? subplana* (Hall).
12. *Byssonychia ?* sp.
13. Pelecypod (undet. sp.).
14. *Platyostoma* sp.
15. *Dalmanites* sp. undet.
16. *Phacops ?* sp. undet.

A short distance south of Hainesville, in an outcrop of sandstone near the base of the Decker Ferry formation, the *Chonetes jerseyensis* fauna is represented by the following species:

1. *Monotrypa* cf. *M. undulata* (Nich.).
2. *Stropheodonta bipartita* (Hall).
3. *Orthothetes* n. sp.
4. *Chonetes jerseyensis* Weller, n. sp.
5. *Camarotoechia neglecta* (Hall).
6. *Atrypa reticularis* (Linn.).

7. *Reticularia bicostata* (Van.).
8. *Dalmanites* sp. undet.

Below Flatbrookville the lower beds of the Decker Ferry formation are finely exposed, and may be seen resting directly upon the Bossardville limestone. At this locality the beds contain a large amount of arenaceous material, but in the more or less calcareous beds intercalated in the sandstone, fossils are abundant, one of the commonest species being *Chonetes jerseyensis.* The following species have been collected at this point:

1. *Favosites* sp. undet.
2. *Monotrypa* cf. *M. undulata* Nich.
3. *Stropheodonta bipartita* (Hall).
4. *Orthothetes* n. sp.
5. *Dalmanella elegantula* (Dal.).
6. *Chonetes jerseyensis* Weller, n. sp.
7. *Camarotoechia neglecta* (Hall).
8. *Rhynchonella* sp. undet.
9. *Atrypa reticularis* (Linn.).
10. *Reticularia bicostata* (Van.).
11. *Whitfieldella?* sp. undet.
12. Ostracodes (sp. undet.).

As will be seen from an examination of the foregoing lists of species, the *Chonetes jerseyensis* fauna is not a large one, but it remains constant in its characters throughout its entire distribution in New Jersey. Aside from the typical species of the fauna from which it has been named, the species of *Monotrypa* which has been compared with *M. undulata* Nich., is an abundant and characteristic species. It is a coral with fine coralities growing in subhemispherical or depressed convex colonies, and in its general external characters resembles some of the corals of similar form from the Trenton limestone illustrated by Hall in his first volume of New York Paleontology under the name *Chætetes lycoperdon.* The cosmopolitan species *Atrypa reticularis* is another characteristic form. The species is always present and is often exceedingly abundant, and is a gibbous, coarsely ribbed variety. The small rhynchonelloid shell which has been identified as *Camarotoechia neglecta* is one of the most common species of the fauna, often being represented by hundreds of individuals crowded together. Some of the other species are abundant, but these constitute the most characteristic and the most noticeable members of the fauna.

Ptilodictya platyphylla zone. In the Nearpass section, lying above the strata containing the *Chonetes jerseyensis* fauna, is a conspicuous band of red limestone, 2 feet 6 inches in thickness. The bed contains a quite different assemblage of fossils from those below, the most abundant species being a bryozoan whose leaf-like colonies occur in vast numbers. In breaking the rock this bryozoan invariably splits along its median plane, so that the outer cell-bearing surface has not been observed. The specimens have been compared with the types of the species described by U. P. James* from the Clinton beds of Ohio as *Ptilodictya platyphylla*, and the two seem to be identical. The form described by Foerste† as *Ptilodictya lanceolata* var. *americana*, is probably identical with James' species and with the New Jersey specimens.

The following species have been identified from this red limestone bed in the Nearpass quarry:

1. *Favosites* sp undet.
2. *Monotrypa ?* sp. undet.
3. *Vermipora ?* sp. undet.
4. *Cladopora* sp. undet.
5. *Stropheodonta bipartita* (Hall).
6. *Orthothetes* n. sp.
7. *Leptæna rhomboidalis* (Wilck.).
8. *Orthis flabellites* Foerste.
9. *Dalmanella elegantula* (Dal.).
10. *Rhipidomella hybrida* (Sow.).
11. *Chonetes jerseyensis* Weller, n. sp.
12 *Pentamerus ovalis* Hall ?
13. *Camarotocchia neglecta* (Hall).
14. *Rhynchonella* sp. undet.
15. *Atrypa reticularis* (Linn.).
16. *Spirifer crispus* (His.).
17. *Ptilodictya platyphylla* Jas.

---

* The Paleontologist, No. 3, p. 21 (Jan 1879).

† Geol. Surv. Ohio, Vol. VII, p. 598, pl. 36, figs. 3 a-b.

18. *Lichenalia ?* sp. undet.
19. Pelecypod (gen. and sp. undet.).
20. *Calymene* sp. undet.

Although several of the species in the above list are also included in the preceding fauna, the assemblage as a whole has quite a different aspect. Among the species common to the two faunas, *Chonetes jerseyensis*, the type species of the preceding fauna will be noticed. In the red limestone, however, but a single, small, imperfect specimen of the species has been observed, so that it is not one of the conspicuous members of the fauna as it had been previously.

Aside from the multitude of specimens of *Ptilodictya*, the following important species make their first appearance: *Orthis flabellites*, *Rhipidomella hybrida*, *Pentamerus ovalis ?* and *Spirifer crispus*. The specimens which have been identified provisionally as *P. ovalis* do not agree well with Hall's original illustrations of this species, but resemble rather closely some specimens of *Gypidula galeatus*, but lack entirely the plications of that species.

Of the whole series of beds recognized in the Nearpass section this red limestone is one of the most persistent in passing to the south. On the farm of G. N. Cole, near the Brick House, a ledge of this limestone is finely exposed and its decomposition has given the soil overlying it a deep red color. Again, at a point north of Hainesville the same bed with its *Ptilodictya* fauna was observed, and at one locality between Peter's Valley and Walpack Center, where the Decker Ferry formation has become almost entirely arenaceous, this red bed was observed with sandstone both above and below. This last occurrence shows better than any other the continuity of the highly arenaceous formation at the south with the almost entirely calcareous formation in the Nearpass section. In the extreme southern end of the ridge neither the red limestone nor the *Ptilodictya* fauna have been observed, but sufficiently careful search has not yet been made south of Walpack Center.

'*Rhynchonella lamellata zone.* Succeeding the red limestone in the Nearpass section there is a series of limestone beds with some shale, with a thickness of 21 feet 4 inches, which is characterized by an assemblage of organisms differing in most of its species from either of the two preceding faunas. One of the most typical species has been described by Hall as *Atrypa lamellata*, but is referred to the genus *Rhynchonella* by Schuchert. For the most part the species in the lower beds of this zone continue to the summit, but in the upper six feet of strata a conspicuous and important coral element is added to the fauna which is not present below, and this upper coral-bearing horizon should perhaps be considered as a distinct subzone. In the lower part of this zone the following species have been identified from the Nearpass quarry:

1. *Cladopora* sp. undet.
2. *Stropheodonta bipartita* (Hall).
3. *Orthothetes interstriatus* (Hall)?
4. *Orthothetes* sp. undet.
5. *Leptæna rhomboidalis* (Wilck.).
6. *Dalmanella elegantula* (Dal.).
7. *Rhynchonella lamellata* (Hall).
8. *Rhynchonella* sp. undet.
9. *Spirifer* sp. undet.
10. *Whitfieldella?* sp.
11. *Phænopora?* sp. undet.
12. *Mytilarca mytiliformis* (Hall).
13. *Pterinea* sp. undet.
14. Pelecypod (gen. and sp. undet.).
15. *Prœtus pachydermatus* Barrett.

In the bluff one and a half miles below Peter's Valley the Decker Ferry formation is exposed through a thickness of more than eighty feet, although the base of the formation is covered. The major portion of the beds at this point are sandstone, but interstratified with the sandstone there are occasionally thin bands of limestone in which the fossils occur in a sufficiently perfect state of preservation to be identified, and the *Rhynchonella lamellata* fauna has been recognized here. From a thin limestone bed fifty feet above the base of the exposure the following species have been identified:

1. *Stropheodonta bipartita* (Hall).
2. *Camarotoechia neglecta* (Hall).
3. *Rhynchonella lamellata* (Hall).

4. *Whitfieldella nucleolata* (Hall).
5. *Phænopora* sp. undet.

From another thin limestone band seventy-five feet from the base the following species were collected:

1. *Diphyphyllum integumentum* Barrett?
2. *Zaphrentis* sp. undet.
3. *Orthothetes interstriatus* (Hall).
4. *Whitfieldella nucleolata* (Hall).
5. Ostracodes (gen. and sp. undet.).

The bed containing the uppermost of these two small faunas may, perhaps, more nearly correspond with the coral bed at the summit of the *Rhynchonella lamellata* zone in the Nearpass section, but the lower one is probably equivalent to the lower portion of the zone.

The earlier stage of the *Rhynchonella lamellata* fauna, as represented in the Nearpass section, is particularly characterized by the species which has been identified in all these faunas as *Stropheodonta bipartita.* Some beds are composed almost exclusively of the shells of this brachiopod, all the other species being sparsely represented. It is the shell for which Dr. Barrett has proposed the name *Stropheodonta nearpassi*,* but an examination of a large series of specimens, showing both the internal and external characters, seems to indicate that the species is no other than Hall's *S. bipartita.* The specimens frequently exhibit the crenulations of the hinge margin which shows it to be a member of the genus *Stropheodonta* rather than *Strophomena*, where it has usually been placed. Some of the beds in this portion of the zone are highly charged with crinoidal remains, to such an extent, even, that it might sometimes be called a crinoidal limestone. These crinoidal remains, however, are for the most part broken fragments of the stems, and no determinable remains have been observed.

In the upper six feet of the *Rhynchonella lamellata* zone in the Nearpass section, a large number of species are added to those which were present in the lower beds, the most conspicuous additions being among the corals. The coral-bearing bed is separated from the lower fossil-bearing beds by about seven feet of barren shales, and the two horizons should perhaps be considered as entirely distinct. It has been thought best, however, to include the entire series in one life zone, as the species in the lower beds are practically identical, so far as they go, with those of the coral bed. From the coral bed proper in the Nearpass quarry, the following species have been identified:

---

*Am. Jour. Sci., (3) Vol. XV, p. 372. (1878.)

1. *Cyathophyllum inequalis* (Hall).
2. *Halysites catenulatus* (Linn.).
3. *Favosites niagarensis* Hall.
4. *Favosites pyriformis* (Hall).
5. *Cladopora seriata* Hall.
6. *Zaphrentis* sp. undet.
7. *Diphyphyllum integumentum* Barrett.
8. *Monotrypa?* sp. undet.
9. *Stromatopora concentrica* Goldf.
10. *Pholidops ovalis* Hall.
11. *Stropheodonta bipartita* (Hall).
12. *Orthothetes interstriatus* (Hall).
13. *Leptæna rhomboidalis* (Wilck.).
14. *Pholidostrophia?* sp. undet.
15. *Camarotoechia neglecta* (Hall).
16. *Rhynchonella pisa* H. & W.
17. *Rhynchonella lamellata* (Hall).
18. *Rhynchonella* sp. undet.
19. *Homeospira sobrina* (B. & C.)?
20. *Whitfieldella nucleolata* (Hall).
21. *Spirorbis* sp. undet.
22. *Pterinea* cf. *P. brisa* Hall.
23. Gasteropod (gen. and sp. undet.).
24. *Calymene camerata* Hall.
25. *Proetus pachydermatus* Barrett.
26. Ostracodes (several species undet.).

The bed containing these corals and other fossils is a more or less earthy or shaly, irregularly bedded limestone. The coral masses occur in great numbers, and the disintegration of the rock leaves the harder coral colonies of several species abundantly strewn over the surface of the exposure. The bed has not been recognized continuously throughout the entire length of the Walpack ridge in New Jersey, the southernmost exposure where the corals occur abundantly being a short distance south of Hainesville. The uppermost of the two limestone bands already mentioned in the bluff below Peter's Valley may belong to this horizon, although the fauna represented is small. Of the five species recognized, two are corals and the *Diphyphyllum integumentum* has not elsewhere been recognized outside of the coral bed.

Correlation of the faunas of the Decker Ferry formation. From the three faunal zones recognized in the Decker Ferry formation, thirty-one species of fossils have been identified specifically with more or less certainty. In the accompanying table an attempt has been made to tabulate the geologic and geographic dis-

LIST OF SPECIES IDENTIFIED FROM THE THREE FAUNAL ZONES INCLUDED IN THE DECKER FERRY FORMATION.	Zone of C. jerseyensis.	Zone of P. platyphylla.	Zone of R. lamellata.	Coralline L. S. of New York.	Clinton beds of New York.	Clinton beds of Ohio and Ind.	Rochester shale.	Lockport limestone.	Waldron shale.	Niagara of the West.
1. *Cyathophyllum inequalis*,	.	.	×	×						
2. *Halysites catenulatus*,	.	.	×	×	×	.	.	×	.	×
3. *Favosites niagarensis*,	.	.	×	×	.	.	.	×	.	×
4. *Favosites pyriformis*,	.	.	×	.	.	.	×	×		
5. *Monotrypa cf. M. undulata*,	×									
6. *Cladopora seriata*,	.	.	×	.	.	.	×	×		
7. *Diphyphyllum integumentum*,	.	.	×							
8. *Stromatopora concentrica*,	.	-	×	×	.	.	.	×		
9. *Stropheodonta bipartita*,	×	×	×	×						
10. *Leptæna rhomboidalis*.	.	×	×	.	×	×	×	×	×	×
11. *Orthothetes interstriatus*,	.	.	×	×						
12. *Orthis flabellites*,	.	×	.	.	.	×	×	.	.	×
13. *Dalmanella elegantula*,	×	×	×	.	×	×	×	.	×	×
14. *Rhipidomella hybrida*,	.	×	.	.	.	×	×	.	×	×
15. *Chonetes jerseyensis*,	×	×								
16. *Pentamerus ovalis?*	.	×	.	.	×					
17. *Camarotoechia neglecta*,	×	×	×	.	×	×	×			
18. *Rhynchonella lamellata*,	.	.	×	×						
19. *Rhynchonella pisa*,	.	.	×	.	.	.		.	.	×
20. *Atrypa reticularis*,	×	×	.	.	×	.	×	×	×	×
21. *Reticularia bicostata*,	×	.	.	.	.	.	.	×		
22. *Spirifer crispus*.	.	×	.	×	.	.	×	.	×	×
23. *Homeospira sobrina?*	.	.	×	.	.	.	.	.	×	
24. *Whitfieldella nucleolata*,	.	.	×	×						
25. *Pholidops ovalis*,	.	.	×	.	.	.	.	.	×	
26. *Ptilodictya platyphylla*.	.	×	.	.	.	×				
27. *Mylilarca mytiliformis*,	×	.	×	.	×	×				
28. *Leptodesma? subplana*,	×	.	.	.		.	×			
29. *Prœtus pachydermatus*,	.	.	×							
30. *Calymene camerela*,	.	.	×	×						
31. *Phacops trisulcutus?*	×	.	.	.	×	×				

tribution of these species. The species are for the most part more or less well-known Niagaran forms, the larger number of them being present elsewhere in beds of post-Clinton age. A single species, *Pentamerus ovalis*, and that one very doubtfully identified, occurs elsewhere only in the Clinton beds of New York. Three species, *Ptilodictya platyphylla*, *Mytilarca mytiliformis*, and *Phacops trisulcatus* have been elsewhere recorded, either from the Clinton beds of Ohio and Indiana, or from both the Clinton of New York and Ohio-Indiana. Even these three species may be considered as somewhat doubtful. No microscopic examination has been made for the purpose of comparing the specimens of *Ptilodictya* from New Jersey and Ohio, and the cell-bearing surface has not been observed in the New Jersey specimens, the identification being made solely upon the general form of the colony—characters which are not sufficiently marked for the satisfactory determination of bryozoa. The *Mytilarca mytiliformis* may be indentical with that species of *Mytilarca* originally described as *Ambonychia acutirostra* from the Niagara linestone of Wisconsin. *Phacops trisulcatus* is an insufficiently known trilobite, and the New Jersey specimens so identified are simply detached pygidia, which may easily belong to some other species. Aside from the four species mentioned, there are several others which occur in Clinton beds elsewhere, but all of them are also present in post-Clinton faunas.

Twenty of the species recorded have never been noted in any Clinton fauna, and all but three of these are more or less well known in various post-Clinton faunas. The three exceptions are, two species, *Chonetes jerseyensis* and *Prœtus pachydermatus*, which have been described from these beds in New Jersey, and the species of *Monotrypa*, which has been compared with an Ordovician species, *M. undulata*, and which will also probably prove to be an undescribed species. All the species which have been identified with absolute certainty are members of post-Clinton faunas. The evidence afforded by the fossils, therefore, indicates that the age of the Decker Ferry formation is the same as the Rochester shale and Lockport limestone of Clarke and Schuchert,* or as the Niagara formation of most authors.

---

* Science, N. S., Vol. 10, No. 259, pp. 874-878. (Dec., 1899.)

In the uppermost faunal zone recognized in the Decker Ferry formation, there is an assemblage of species which indicates the equivalence of this portion of the formation and the Coralline limestone of Schoharie, New York. Especially is this true of the upper six feet or the coral-bearing horizon of the formation. The species which especially ally this zone with the Coralline limestone are *Cyathophyllum inequalis*, *Stropheodonta bipartita*, *Orthothetes interstrialis*, *Rhynchonella lamellata*, *Whitfieldella nucleolata* and *Calymene camerata*. There are, however, in the Coralline limestone at its typical locality, Schoharie, New York, many large gasteropods and some cephalopods which are conspicuously absent in New Jersey.

In his description of the Coralline limestone, Hall* expresses the opinion that the formation represents the entire Niagaran series of other localities, but its occurence in New Jersey would indicate that it represents only the last stage of that epoch.

In the official reports on the Walpack ridge in New Jersey, published by the geological surveys of both New Jersey and Pennsylvania, no strata of either Clinton or Niagara age have been recognized. They have been recognized, however, in the Nearpass section by Dr. S. T. Barrett,† a local geologist of Port Jervis, New York, and to him credit is due for the first announcement of the presence of strata in the New Jersey section referable to the Coralline limestone of eastern New York. Although the presence of the Coralline limestone fauna was recognized by Dr. Barrett, he did not in either of his papers strictly define the limits of the zone bearing it, leaving the reader of his papers to infer that it included a large portion or all of the beds here referred to the Decker Ferry formation. Strictly speaking, only the six-foot coral bed can be referred with certainty to the Coralline limestone. This coral bed was fully recognized by Prof. Cook,‡ but because of his erroneous correlation of the "ribbon limestone" of New Jersey with the Manlius or "Tentaculite" limestone of New York, he failed to recognize the identity of this coral bed with the Coralline limestone.

---

* Pal. N. Y., Vol. II, p. 321.

† Ann. N. Y. Acad. Sci., Vol. 1, pp. 121-124 (1878). Am. Jour. Sci. (3), Vol. 15, pp. 370-372 (1878).

‡ Geol. of N. J., p. 159 (1868).

Correlation of the Bossardville limestone and the Poxino Island shale. With the correlation of the fossiliferous Decker Ferry formation and the Rochester shale and Lockport limestone of Clarke and Schuchert, or the Niagara formation of most authors, and with the probable continuity of the red sandstone of the Kittatinny mountain with the Medina sandstone of New York, the Bossardville limestone and the Poxino Island shale are left as the representatives of the intermediate Clinton beds of the New York section, and although these two formations have as yet yielded no fossil remains, they will for the present be so correlated.

RONDOUT WATER-LIME FORMATION.

In the Nearpass section the coral bed at the summit of the Decker Ferry formation is followed by 56 feet of strata which may be referred to the Water-lime formation. These strata are very diverse in character, consisting of many alternating beds of shales and limestones of varying characters. The following section is an attempt to subdivide this series of strata, but in many instances the subdivisions might be made still smaller.

1.	Hard blue limestone with bands of shale,	4 ft.
2.	Earthy shales, with bands of limestone,	3 ft. 9 in.
3.	Fine-grained dark limestone,	6 ft. 4 in.
4.	Thick bedded calcareous shale,	1 ft. 6 in.
5.	Hard blue limestone filled with Ostracodes and Stromatopora,	2 ft. 3 in.
6.	Fissile buff or greenish shale,	5 ft. 3 in.
7.	Dense, fine-grained, compact limestone, bluish on freshly fractured surfaces, but buff or yellowish upon the weathered surface,	5 ft
8.	Fissile gray shales, sometimes much crumpled by pressure,	15 ft.
9.	Bluish black limestone,	13 ft.
		56 ft 1 in.

The most conspicuous member of this series of strata is bed No. 7. This is the "Peth Stone"* of Prof. Cook's report, and is the southern extension of the cement rock which is so extensively quarried at Rosendale and Rondout, New York. This bed in New Jersey possesses the same lithologic characters as the cement beds at Rondout, and has the same stratigraphic position. During a visit to Rondout in company with Prof. J. C. Smock and Dr. H. B. Kümmel, the Coralline limestone, with some of the same corals as are found in New Jersey, was observed underlying the cement rock, while above it was the Manlius or "Tentaculite" limestone containing the same *Spirifer vanuxemi* fauna that is present in the same formation overlying the Waterlime formation in the Nearpass section. The chief and only difference between the Water-lime formation at Rondout and in the Nearpass section, is the much greater development of the cement bed in the former locality at the expense of the accessory beds of shales and limestones which are so well exhibited in the Nearpass section.

---

* Geol. N. J., p. 159 (1868).

In passing southward from the Nearpass quarry, the Waterlime formation diminishes in thickness until at the Walpack bend of the Delaware river, on the Pennsylvania side near Decker's Ferry, only the "peth stone" with an underlying bed of fine-grained blue limestone is present, both together being not more than 20 or 25 feet in thickness. This blue limestone underlying the "peth stone" is White's* Decker Ferry limestone already mentioned on a previous page.

The fauna of the Water-lime formation is a peculiar one, being constituted almost exclusively of ostracodes. The successive beds in the Nearpass section were examined closely for these small organisms, and each separate bed was found to contain its own peculiar forms, many of which probably belong to undescribed species. Associated with the ostracodes in some of the beds there are immense numbers of stromatoporoids. In the lowermost bed of the whole formation, in a thin limestone band, two specimens of pelecypods were found associated with the ostracodes.

The real significance of these ostracode faunas is not entirely clear, but they must certainly indicate some important physical change. In the Decker Ferry formation we find a prolific fauna of such organisms as usually occur under typical marine conditions, brachiopods, corals, trilobites, pelecypods, etc., containing also a goodly number of individual ostracodes. With no apparent break in the stratigraphic succession, this well-defined marine fauna is followed by a whole series of faunas consisting of almost no other organisms than ostracodes. At the present time ostracodes are inhabitants of both fresh and salt water, while the brachiopods and corals are exclusively marine in their habitat, and the trilobites, though extinct at the present time, are believed also to have been wholly marine organisms. If at the close of the Niagaran epoch in the interior of North America, marine conditions were followed by fresh-water or non-marine conditions, the extinction of the marine types of life such as the brachiopods, corals and trilobites would be accounted for, as well as the persistence of the non-marine ostracodes. With the return of marine conditions the marine types of life would also return, just as they do in the Manlius or "tentaculite" limestone overlying the Water-lime formation in the Nearpass section.

---

* 2d Geol. Surv. Penn., Rep. G6, p. 137

The organic evidence of the non-marine origin of the Water-lime sediments is not confined to the New Jersey area, but wherever the formation is recognized it is characterized by the absence of marine fossils and by the presence of peculiar organic remains, which are believed to be fresh-water or, at least, non-marine forms. The peculiar crustacean or arachnoid genera *Eurypterus* and *Pterogotus*, which are so characteristic of the Water-lime formation in some of its western New York exposures, are nowhere found associated with true marine types of life, but they do occur in other non-marine formations, as, for instance, in Coal Measure strata in Pennsylvania,* associated with the remains of land plants which were in all probability deposited in fresh waters.

The presence of this widespread non-marine formation in the interior of North America is of prime significance. It shows that following the wide-spread interior epicontinental sea of Silurian time†—a sea that had reached from the Appalachian land on the east to beyond the Mississippi river, and from the western extension of the Appalachian land at the south far into the Arctic regions—some readjustment of the earth's crust was accomplished by reason of which the communication between the interior sea and the external ocean was destroyed. During the whole of Silurian time stresses had been accumulating in the earth's crust until a general readjustment became essential. This readjustment is believed to have been universal and not local in nature, and the major movements of the earth's crust accompanying it are believed to have been the sinking of the ocean bottoms,* which caused the withdrawal of the waters from the continents.

---

* 2d Geol. Surv. Penn., Rep. P3, pp. 23-39.

† Jour. Geol., Vol. VI, p. 697.

Following the period of readjustment, the waters confined in the interior by the elevated rim of the continent, became a landlocked sea inhabited by non-marine types of life. In the shallow seas upon the outer borders of the continent which were not drained by the recession of the oceanic waters, and in such moderately deep seas as became shallow by reason of the depression of the ocean level, conditions favorable for the development of shallow-water marine life persisted during this period of readjustment, and in such areas the evolution of marine life continued without interruption. A notable example of such a border province at this time, was in eastern Canada, in the region of the St. Lawrence embayment. Here the shallow-water marine life continued its evolution without the wide-spread extinction caused by the intervention of non-marine conditions such as occurred in the interior of the continent.

This period of readjustment of the earth's crust constitutes a natural geologic time division which is believed to have a worldwide significance. Just as the non-marine deposits of the Medina epoch represent the natural division between the Ordovician and Silurian periods, so these non-marine water-lime beds represent the natural division between the Silurian and Devonian. On the borders of the continents in the "harbors of refuge" where the shallow-water marine conditions were continuous, the conspicuous life-breaks which are so noticeable in the interior of the continents are not present; so in the eastern provinces of Canada there is no such discontinuity between the Silurian and Devonian life as is recognized in the interior.

After the accomplishment of the readjustment of conditions a gradual transgression of the sea upon the continent was initiated. This transgression was caused (1) by the slight settling of the continental borders which may have been forced out of isostatic equilibrium during the period of readjustment; (2) by the landward cutting of the continental border, and (3) by the transportation of materials from the continent and their deposition in the ocean. With the extension of the shallow marine waters towards the interior, a union was at last established between the exterior and interior shallow seas. With the renewal of this connection, the marine, Devonian, interior, epicontinental sea came into existence and the shallow-water marine life again found its way to the interior of the continent, the derivation of this life being from those faunas which had persisted in the shallow waters on the outer borders of the continent during the readjustment period. This re-introduction of marine faunas into the interior initiates the Helderbergian epoch and the Devonian period.

---

*For a further discussion of this, see "The Ulterior basis of time divisions and the classification of Geologic History," by T. C. Chamberlin. Jour. Geol., Vol VI, pp. 449-462.

Formations of the Devonian System.

MANLIUS LIMESTONE.

Spirifer vanuxemi zone. Lying upon the Rondout Waterlime formation in the Nearpass section there is a series of 22 feet of thinly-bedded, knotty, dark blue or almost black limestones, referable to the Manlius or "Tentaculite" limestone of the New York section. This is the bed which constitutes the quarry stone, and its outcrop may be traced throughout the entire length of the Walpack ridge in New Jersey by the line of quarries and limekilns, it being the only* limestone of the region suitable for the manufacture of lime.

The fauna of the Manlius limestone is not a large one. Ostracodes still persist, but associated with them are several species and many individuals of brachiopods, gasteropods, and some cephalopods. The fauna represents the first return of marine conditions after the non-marine Water-lime epoch. In the Nearpass quarry, fossils were collected from two horizons in this formation, one near the base and the other near the summit. From the lower zone at this locality the following species have been identified:

1. *Stropheodonta varistriata* (Con.).
2. *Spirifer vanuxemi* Hall.

---

* At Flatbrookville the Bossardville limestone and the calcareous beds of the Decker Ferry formation are occasionally burnt for lime. Near the Delaware Water Gap in Pennsylvania, the Bossardville limestone has been used for years in making lime both for building and agricultural purposes.

3. *Megambonia aviculoidea* Hall?
4. *Holopea antiqua* (Van.).
5. *Tentaculites gyracanthus* (Eaton).
6. Cephalopod (gen. and sp. undet).
7. *Leperditia alta* (Con.).
8. Ostracodes (several species).

From the upper zone at the same locality the following species have been identified:

1. *Stropheodonta varistriata* (Con.).
2. *Gypidula galeata* (Dal.).
3. *Spirifer vanuxemi* Hall.
4. Gasteropods (several species).
5. *Orthoceras*, sp. undet.
6. Ostracodes (several species).

The most conspicuous species in this fauna are *Spirifer vanuxemi* and *Stropheodonta varistriata*, and for the lower beds *Leperditia alta* may be added to these. All the other species are more or less uncommon. In the upper half of the formation there are various thin bands closely crowded with gasteropod shells, but they are so firmly imbedded in the matrix that their characters cannot easily be made out, and as a usual thing they can only be recognized in cross section on the weathered surface of the quarry face. At various localities along the entire length of the Walpack ridge the *Spirifer vanuxemi* fauna of the Manlius limestone was observed, but it will not be necessary to give further lists of species.

There has been, and is at the present time, some diversity of opinion among American geologists and paleontologists as to the proper line of separation between the Silurian and Devonian systems. In the past this line has usually been placed between the Helderberg and Oriskany formations, but more recently Clarke and Schuchert* have become the chief advocates of placing it down so as to include the Helderberg formations in the Devonian. The impracticability of drawing any line of demarcation between two of the major divisions of the geologic time scale at the Helderberg-Oriskany contact horizon, is strongly brought out to any student of the stratigraphic paleontology of eastern New York or New Jersey. There is at this horizon no stratigraphic break, impure shales and cherty limestone beds being continuously represented in the section, and the differentiation of the fossil faunas is no more satisfactory. The faunal break is more conspicuous in New Jersey between the Coeymans limestone and the New Scotland beds than between the summit of the Helderbergian series and the Oriskany beds. The alliance of the Helderbergian faunas is upward to a far greater extent than downward, and in the uppermost faunal zone there is a conspicuous mingling of species which have usually been considered either as characteristic of the Helderberg or of the Oriskany faunas.

---

*Science, N. S., Vol. X, pp. 874-878.

Among those opposed to the inclusion of the Helderbergian series in the Devonian, the chief ground of appeal is to the original Silurian system in England as described by Murchison, the contention being made that faunas equivalent to his highest Silurian fauna are present above the Helderberg in America. But even if this contention is true, it should not of necessity establish the Silurian age of the Helderbergian series. In the classification of geologic time into its major subdivisions, it is possible to push the doctrine of priority too far. What the present day geologist is seeking is a natural and satisfactory classification of geologic time, not what was the classification of Murchison or any other of the fathers of geology. With our vastly increased insight into paleontology and stratigraphy, it is unreasonable to hold that the present-day geologist is not able to improve on the classifications of the past. No one should allow his sentimental respect for the labors of the fathers of geology, important as they undoubtedly were, to stand in the path of improvement and progress. It is, of course, best to adopt the earlier classification in so far as it can be adjusted to our more perfect understanding of the facts, but it is not in the line of progress to bind ourselves to the arbitrary limits established long ago for the major divisions of the time scale, when we are now able to establish more natural ones.

In the present report the Helderbergian formations are considered as of Devonian age, but the writer differs from Clarke and Schuchert in his estimate of the Manlius limestone. These authors have placed this formation at the summit of the Silurian, linking it with the subjacent Water-lime formation as has been the usual custom in the past, rather than with the superjacent formations. The fauna of the Manlius limestone, with its marine types of life, differs conspicuously from that of the Water-lime formation which is characterized by its non-marine life. On the other hand the two most characteristic species of the Manlius limestone fauna, *Spirifer vanuxemi* and *Stropheodonta varistriata* are both present in the *Gypidula galeata* fauna of the superjacent beds, the first one being rarely represented and the second often being abundant in the higher fauna. Then again, *Gypidula galeata*, the most characteristic species of the beds superjacent to the Manlius limestone, is sometimes present in the *Spirifer vanuxemi* fauna. Under these conditions it seems as difficult to draw one of the major division lines of the geologic time scale at the summit of the Manlius limestone as at the summit of the Helderbergian series.

It would seem to be far better for the purposes of a natural classification of geologic time, to consider the non-marine Water-lime formation as the division between the Silurian and Devonian periods, beginning the latter period with the first re-initiation of marine life into the interior of the continent. This non-marine horizon is a widespread one in eastern North America, and it is believed that it will be found to represent a terrestrial period which was more or less world-wide in its distribution. In Europe this non-marine horizon is indicated by the presence of strata in Scotland and on the continent containing a peculiar Eurypterus fauna similar to that in the American Water-lime formation, but the symmetrical continental development of Europe was far less perfect than that of North America, and there are in England no marine beds corresponding to our Helderbergian series.

It is believed that a complete elucidation of the earth's history will show an alternation of terrestrial and marine conditions upon the continental platforms, and that these alternations will be found to be more or less world-wide in their distribution. These alternations, then, will form a basis for a natural classification of geologic time, as has been suggested by Chamberlin.* If this hypothesis shall prove to be tenable, it will be seen that the paleontologic record of the continental interior will usually exhibit an alternation of marine and non-marine faunas, the terrestrial periods being represented either by sediments with non-marine life or by no sedimentation at all. On the continental borders, however, marine conditions will have been continuous and no such great life-breaks may be looked for.

---

* Jour. Geol., Vol. VI, p. 449.

In North America this contrast between the interior and border provinces is strikingly brought out, both in the Ordovico-Silurian and the Siluro-Devonian transitions. In the first instance we have the continuity of life in the Anticosti formation of eastern Canada, while the Medina formation, probably non-marine in origin, fills the interval in the continental interior.* In the same border province there is a continuity of Silurian and Devonian life, while in the interior the transitional terrestrial period is indicated by the Salina and Water-lime formations with non-marine life.

COEYMANS LIMESTONE.

Gypidula galeata zone. At the top of the bluff in the Nearpass quarry, lying upon the Manlius limestone and scarcely separable from it stratigraphically, are other limestone beds which gradually assume a coarser texture and often become more or less cherty. This formation is what has usually been known as the "Lower Pentamerus limestone," but for which Clarke and Schuchert† have recently proposed the more satisfactory name Coeymans limestone. This formation differs from the Manlius limestone not only in texture and other lithologic characters, but also in containing a far more prolific fossil fauna. The most characteristic species of the fauna is *Gypidula galeata*, a species formerly included in the genus *Pentamerus*, hence the older name of the formation.

In the Nearpass section the thickness of this formation has been estimated at 40 feet, though only the lower beds are here actually exposed. There are in the formation as it is exhibited in the various outcrops in the area under discussion, several more or less distinct sub-zones of the *Gypidula galeata* fauna. All of these sub-zones contain the type species of the formation, but not all of them contain it in the same relative numerical abundance. Only the lowermost of these sub-faunas has been traced with any degree of continuity through the entire length of the Walpack ridge, and even this one has not as yet been so clearly recognized in the extreme southern portion of the area as it has at the north.

---

* See "The Silurian Fauna Interpreted on the Epicontinental Basis," by Stuart Weller, Jour. Geol., Vol. VI, pp. 692-707

† Science, N. S., Vol. X, pp. 874-878.

The fauna of the basal portion of the *Gypidula galeata* zone is characterized by its large number of corals of the genus *Favosites*, and by the genus *Stromatopora*. It is really a southern extension of the coral bed, recognized at the base of the same formation in New York. Near the top of the Nearpass bluff this bed may be easily traced by the large number of Favosites which have become conspicuous in the weathered surface. In the Nearpass quarry the following species have been identified from the Favosites bed:

1. *Favosites helderbergiæ* Hall.
2. *Favosites sphericus* Hall.
3. *Stromatopora concentrica* Goldf.
4. *Stropheodonta varistriata* (Con.).
5. *Stropheodonta beckei* Hall.
6. *Strophonella punctulifera* (Con.).
7. *Dalmanella perelegans* Hall.
8. *Gypidula galeata* (Dal.).
9. *Rhynchonella semiplicata* (Con.).
10. *Rhynchonella transversa* Hall.
11. *Uncinulus mutabilis* Hall.
12. *Atrypa reticularis* (Linn.).
13. *Spirifer octocostatus* Hall. ?
14. *Meristella lævis* (Van.)?
15. *Lichenalia torta* Hall.
16. *Ptilodictya ?* sp. undet.
17. *Pterinea* cf. *P. textilis* (Hall).
18. *Capulus* sp. undet.
19. *Dalmanites* sp. undet.
20. *Phacops* sp. undet.

At Peter's Valley the Coeymans limestone is well exposed in the hillside above the large spring one-half mile northeast of the village, and again in the hillside above the school-house.

The coral bed is not so well exposed in this locality, but *Gypidula galeata* is remarkably abundant, it being represented by hundreds of individuals, while most of the other species present are more or less rare. The following species have been identified from Peter's Valley above the large spring:

1. *Zaphrentis* sp. undet.
2. *Stropheodonta varistriata* (Con.).
3. *Strophonella punctulifera* (Con.).
4. *Dalmanella perelegans* Hall. ?
5. *Gypidula galeata* (Dal.).
6. *Rhynchonella semiplicata* (Con.).
7. *Uncinulus mutabilis* Hall.
8. *Lissopleura æquivalvis* (Hall).
9. *Atrypa reticularis* (Linn.).
10. *Spirifer vanuxemi* Hall.
11. *Meristella lævis* (Van.)? small form.
12. *Rhynchospira formosa* Hall.
13. *Lichenalia torta* Hall.
14. *Conocardium* sp. undet.
15. *Megambonia ?* sp. undet.
16. *Tentaculites* sp. undet.
17. *Dalmanites* sp. undet.
18. Ostracodes (several species).

At Flatbrookville the Coeymans limestone is well developed, and in a bed lying near the top of the formation the species collected were the following:

1. *Stropheodonta varistriata* (Con.).
2. *Stropheodonta beckei* Hall.
3. *Strophonella punctulifera* (Con.).
4. *Orthothetes woolworthanus* Hall.
5. *Schizophoria multistriata* Hall.
6. *Gypidula galeata* (Dal.).
7. *Rhynchonella semiplicata* (Con.).
8. *Uncinulus mutabilis* Hall.
9. *Uncinulus pyramidatus* Hall.
10. *Atrypa reticularis* (Linn.).
11. *Spirifer octocostatus* Hall. ?
12. *Cyrtina dalmani* (Hall).

13. *Meristella lævis* (Van.)? small form.
14. *Rhynchospira formosa* Hall.
15. *Lichenalia torta* Hall.
16. *Fenestella?* sp. undet.
17. *Pterinea* sp. undet.
18. *Tentaculites* sp. undet.
19. *Dalmanites* sp. undet.
20. *Phacops* sp. undet.

At a single locality, north of Hainesville, a fauna was collected which is believed to have come from the very summit of the Coeymans limestone. The particular variety of *Gypidula galeata* which is present in the lower portion of the formation is not abundant in this locality, although it is rarely represented. Most of the specimens of this species which do occur here have a more pronounced fold and sinus which is marked by coarser plications, the sides of the shell being nearly smooth. The following species have been identified from this locality:

1. *Zaphrentis roemeri* E. & H.?
2. *Favosites helderbergiæ* Hall.
3. Coral (gen. and sp. undet.).
4. *Gypidula galeata* (Dal.).
5. *Rhynchonella semiplicata* (Con.).
6. *Rhynchonella* sp. undet.
7. *Uncinulus pyramidatus* Hall.
8. *Atrypa reticularis* (Linn.).
9. *Spirifer octocostatus* Hall.
10. *Spirifer concinnus* Hall.
11. *Cyrtina dalmani* Hall.
12. *Nucleospira* cf. *N. concentrica* Hall.
13. *Rhynchospira formosa* Hall.
14. *Meristella lævis* (Van.).
15. *Lichenalia torta* Hall.
16. *Fenestella* sp. undet.
17. *Cornulites* sp. undet.
18. *Pterinea textilis* Hall.?
19. *Rhombopteria* cf. *R. mira* Barr.
20. *Capulus gibbosum* (Hall).
21. *Holopea?* sp. undet.
22. *Murchisonia* sp. undet.

This fauna is quite different in its general composition from any of those in the lower beds of the Coeymans limestone, one of its most conspicuous characteristics being the entire absence of the genera *Stropheodonta* and *Strophonella*. In the increased representation of the genus *Spirifer*, the fauna shows its approach towards those of the superjacent New Scotland beds, but on account of the presence of *Gypidula galeata* the beds containing it are included in the Coeymans limestone.

NEW SCOTLAND BEDS.

In New York the Coeymans limestone is followed by a series of beds formerly known as the Catskill or Delthyris Shaly limestone, but for which Clarke and Schuchert* have proposed the name New Scotland beds. This formation contains a wonderfully prolific fauna, especially characterized by the large representation of the genus Spirifer, standing in sharp contrast in this respect to the faunas of the Coeymans limestone. The New Scotland beds are extended into New Jersey, where they are well represented and contain a fauna which is in general identical with that in New York. In New Jersey this fauna as a whole is differentiated into three more or less distinct faunal zones, while in New York, so far as can be determined from the literature, the species constitute one general assemblage of life.

These beds are well exhibited in the Nearpass section, although they are not exposed at any point in the quarry bluff. At this locality three distinct beds are recognized in the formation as a whole, a cherty limestone at the base and another at the summit, with a shale bed between. These three beds have been recognized throughout a large part of the area under discussion, but they have not been so clearly differentiated at the extreme southern end of the ridge as at the north.

Each of the three beds of this formation is characterized by some species which are more or less restricted to it, and these somewhat distinct faunal zones will be spoken of as the *Spirifer perlamellosus* zone, the *Spirifer macropleurus* zone, and the *Spirifer cyclopterus* zone, from that species of Spirifer which is most characteristic of each.

---

* Science, N. S., Vol. X, pp. 874-878.

Toward the southern part of the Walpack ridge in New Jersey there is intercalated between the Coeymans limestone and the New Scotland beds a sandstone formation which continues southwestward into Pennsylvania, where it becomes conglomeratic in places. To this formation White* has given the name Stormville conglomerate. At Flatbrookville this sandstone seems to replace the lower cherty limestone member of the New Scotland beds. A few notes upon this formation will be added after the discussion of the New Scotland beds.

Spirifer perlamellosus zone. The lowest member of the New Scotland beds is an impure cherty limestone, some beds of which in certain localities are constituted almost entirely of chert. The commonest species of *Spirifer* which has been found in this bed is *S. perlamellosus*, and from this species the faunal zone has been named. This species, however, is not restricted to this horizon alone, as it also occurs in the superjacent shale beds.

In the Nearpass section this bed is for the most part covered with drift, but just above the quarry of Mr. Sanford Nearpass a good outcropping ledge is exposed, from which the following species were collected:

1. *Hindia fibrosa* (Roem.).
2. *Streptelasma strictum* Hall.
3. *Lecanocrinus* sp. undesc.
4. *Pholidops ovata* Hall?
5. *Stropheodonta beckei* Hall.
6. *Strophonella punctulifera* (Con.).
7. *Strophonella* sp. undet.
8. *Leptæna rhomboidalis* (Wilck.).
9. *Dalmanella perelegans* Hall.
10. *Rhipidomella oblata* Hall.
11. *Bilobites varicus* (Con.).
12. *Scenidium insigne* Hall.
13. *Uncinulus pyramidatus* Hall.
14. *Eatonia medialis* (Van.).
15. *Spirifer perlamellosus* Hall.
16. *Spirifer cyclopterus* Hall.

---

* 2d Geol. Surv. Penn., Rep. G6, p 132.

17. *Nucleospira concentrica* Hall.
18. *Meristella lævis* (Van.).
19. *Pterinea* sp., cf. *P. textiles* (Hall).
20. *Platyostoma* sp. undet.
21. *Dalmanites pleuropteryx* (Green). ?
22. *Phacops* sp. undet.

Just below Hainesville there is another good exposure of this bed and from it the following species have been identified:

1. *Hindia fibrosa* (Roem.).
2. *Glossina spatiosa* (Hall). ?
3. *Stropheodonta beckei* Hall.
4. *Strophonella punctulifera* (Con.).
5. *Strophonella levenworthana* Hall.
6. *Leptæna rhomboidalis* (Wilck.).
7. *Dalmanella perelegans* Hall.
8. *Dalmanella subcarinata* Hall.
9. *Rhipidomella oblata* Hall.
10. *Rhipidomella eminens* Hall.
11. *Orthothetes woolworthanus* Hall.
12. *Uncinulus vellicatus* Hall.
13. *Eatonia singularis* (Van.).
14. *Eatonia medialis* (Van.).
15. *Spirifer perlamellosus* Hall.
16. *Meristella lævis* (Van.).
17. *Pterinea spinulifera* (Hall).
18. *Pterinea* sp. undet.
19. *Megambonia ovata* Hall. ?
20. *Cypricardinia sublamellosa* Hall. ?
21. *Loxonema attenuata* Hall. ?
22. *Strophostylus gebhardi* (Con.).
23. *Orthoceras* sp. undet.
24. *Phacops logani* Hall.
25. *Dalmanites* sp. undet.

Spirifer macropleurus zone. The intermediate member of the New Scotland beds is usually a rather soft earthy shale. In most localities this bed is drift-covered, but several good exposures of it have been observed, it seeming to exhibit greater continuity than either the subjacent or superjacent beds of the formation. This shale is particularly characterized by the presence of *Spirifer macropleurus*, a species which has not yet been observed at any other horizon in New Jersey, and therefore this horizon has been designated as the *Spirifer macropleurus zone.*

In the Nearpass section this shale bed occupies the first hollow beyond the summit of the Nearpass quarry bluff, only a few limited exposures of it being visible. The following species have been collected at this locality:

1. *Streptelasma strictum* Hall.
2. *Stropheodonta beckei* Hall.
3. *Leptæna rhomboidalis* (Wilck.).
4. *Rhipidomella oblata* Hall.
5. *Eatonia medialis* (Van.).
6. *Spirifer macropleurus* (Con.).
7. *Spirifer cyclopterus* Hall.
8. *Spirifer perlamellosus* Hall.
9. *Trematospira multistriata* Hall.
10. *Meristella arcuata* Hall.
11. *Anoplotheca concava* (Hall).
12. *Pterinea communis* (Hall.)
13. *Cypricardinia lamellosa* Hall.
14. *Tentaculites* sp. undet.
15. *Dalmanites* sp. undet.

About a mile and a half south of the Nearpass quarry, in the east side of the ridge, a small excavation has been made in this shale. At this locality fossils are preserved in abundance and the following species have been identified.

1. *Stropheodonta beckei* Hall.
2. *Strophonella punctulifera* (Con.).
3. *Leptæna rhomboidalis* (Wilck.).
4. *Rhipidomella oblata* Hall.
5. *Eatonia medialis* (Van.).
6. *Spirifer macropleurus* (Con.).
7. *Spirifer cyclopterus* Hall.
8. *Spirifer perlamellosus* Hall.
9. *Atrypina imbricata* Hall.
10. *Meristella arcuata* Hall.
11. *Anoplotheca concava* (Hall).

Below Hainesville, lying above the bed from which the fauna of the *Spirifer perlamellosus* zone has already been recorded, this shale bed is well exposed and has furnished the following species:

1. *Stropheodonta beckei* Hall.
2. *Leptæna rhomboidalis* (Wilck.)
3. *Rhipidomella oblata* Hall.
4. *Eatonia medialis* (Van.).
5. *Uncinulus vellicatus* Hall.
6. *Spirifer macropleurus* (Con.).
7. *Spirifer cyclopterus* Hall.
8. *Trematospira multistriata* Hall.
9. *Atrypina imbricata* Hall.
10. *Meristella arcuata* Hall.
11. *Anoplotheca concava* (Hall).

About one mile below Peter's Valley, in the side of the road crossing the ridge, an excavation for road material has been made in this shale. Some of the beds at this locality are fossiliferous and the following species have been identified:

1. *Stropheodonta beckei* Hall.
2. *Leptæna rhomboidalis* (Wilck.).
3. *Rhipidomella oblata* Hall.
4. *Orthostrophia strophomenoides* Hall.
5. *Eatonia medialis* (Van.).
6. *Spirifer macropleurus* (Con.).
7. *Spirifer cyclopterus* Hall.
8. *Spirifer perlamellosus* Hall.
9. *Trematospira multistriata* Hall.
10. *Atrypina imbricata* Hall.
11. *Meristella arcuata* Hall.

At Flatbrookville, just below the village, the *Spirifer macropleurus* bed is exposed, lying directly upon the Stormville sandstone, indicating that at this locality the sandstone has replaced the basal, cherty limestone member of the New Scotland beds. These shale beds at this point are a much tougher and more calcareous rock than at the localities that were examined further north. The following species of fossils were collected at Flatbrookville:

1. *Streptelasma strictum* Hall.
2. *Stropheodonta beckei* Hall.
3. *Leptæna rhomboidalis* (Wilck.).
4. *Orthostrophia strophomenoides* Hall.
5. *Rhipidomella oblata* Hall.
6. *Eatonia medialis* (Van.).
7. *Spirifer macropleurus* (Con.).
8. *Meristella arcuata* Hall.
9. *Dalmanites* sp. undet.

Spirifer cyclopterus zone. The uppermost member of the New Scotland beds in the Nearpass section, is exposed along the crest of the first low ridge back of the summit of the Nearpass quarry bluff. This bed is an extremely cherty limestone, which makes a rather continuous outcrop because of its power of resistence to the weather. It is often highly fossiliferous, but the fossils are usually so firmly imbedded in the cherty matrix that it is difficult to make satisfactory identifications of the species. This cherty limestone has been observed at several points along the ridge, but the only locality where the fauna has been made out with any degree of satisfaction is in the Nearpass section from which locality the following species have been identified:

1. *Zaphrentis* sp. undet.
2. *Stropheodonta beckei* Hall.
3. *Stropheodonta planulata* Hall.
4. *Strophonella punctulifera* (Con.).
5. *Leptæna rhomboidalis* (Wilck.).
6. *Rhipidomella oblata* Hall.
7. *Uncinulus vellicatus* Hall.
8. *Rhynchotrema formosum* (Hall).
9. *Rhynchonella bialveata* Hall.
10. *Spirifer cyclopterus* Hall.
11. *Meristella lævis* (Van.).
12. *Pterinea textiles* (Hall).
13. *Phacops logani* Hall.
14. *Homalonotus vanuxemi* Hall.
15. *Lichas pustulosus* Hall.

16. *Dalmanites* sp. undet.
17. Ostracodes (several undet. sp.).

Vertical range of species in the New Scotland beds. For the purpose of comparing the faunas of the three members recognized in the New Scotland beds, the following table has been prepared:

LIST OF SPECIES.	S. perlamellosus zone.	S. macropleurus zone.	S. cyclopterus zone.
Hindia fibrosa,	×		
Streptelasma strictum,	×	×	
Lecanocrinus sp. undet.,	×		
Pholidops ovatus,	×		
Glossina spatiosa,	×		
Stropheodonta beckei,	×	×	×
Stropheodonta planulata,			×
Strophonella punctulifera,	×	×	×
Strophonella levenworthana,	×		
Leptæna rhomboidalis,	×	×	×
Dalmanella perelegans,	×		
Dalmanella subcarinata,	×		
Rhipidomella oblata,	×	×	×
Rhipidomella eminens,	×		
Bilobites varicus,	×		
Scenidium insigne,	×		
Orthothetes woolworthanus,	×		
Orthostrophia strophomenoides,		×	
Uncinulus pyramidatus,	×		
Uncinulus vellicatus,	×	×	×
Rhynchotrema formosa,			×
Rhynchonella bialveata,			×
Eatonia medialis,	×	×	
Eatonia singularis,	×		
Atrypina imbricata,		×	
Spirifer perlamellosus,	×	×	
Spirifer macropleurus,		×	
Spirifer cyclopterus,	×	×	×
Nucleospira concentrica,	×		
Trematospira multistriata,		×	
Meristella lævis,	×		×
Meristella arcuata,		×	
Anoplotheca concava,		×	
Pterinea textilis			×
Pterinea spinulifera,	×		
Pterinea communis,		×	
Megambonia ovata,	×		
Cypricardinia lamellosa,		×	
Cypricardinia sublamellosa,	×		
Loxonema attenuata,	×		
Strophostylus gebhardi,	×		
Dalmanites sp.,		×	×
Phacops logani,	×		×
Homalonotus vanuxemi,			×
Lichas pustulosus.			×

STORMVILLE SANDSTONE.

This formation is present only in the southern half of the area, where it lies immediately above the Coeymans limestone. It makes its first appearance just south of Hainesville, where it occurs as a thin sandy layer in the top of the Coeymans limestone. South of this locality, for some distance, this sandstone is not a conspicuous formation. It is too thin a bed and is too heavily drift-covered to afford noticeable exposures. Below Peter's Valley, however, it becomes more strongly developed and is frequently met with. A good exposure of it may be seen in the side of the road crossing the ridge at Walpack Center. At one locality above Walpack Center this formation contains numerous fossils, but they are all imperfect casts and cannot be identified with any certainty, though most of them appear to be identical with species which occur in the *Spirifer perlamellosus* zone of the New Scotland beds. At Flatbrookville this sandstone occurs, and from the base of the formation specimens of *Gypidula galeata* were collected, while the beds lying above it contain the fauna of the *Spirifer macropleurus* zone, which indicates that at this locality the Stormville sandstone has replaced the lower cherty limestone member of the New Scotland beds.

According to the report on Pike and Monroe counties, Pennsylvania,* the Stormville sandstone becomes more and more a conspicuous formation to the south, and gradually replaces the remaining members of the New Scotland beds and also the superjacent strata until it becomes continuous with the Oriskany sandstone.

BECRAFT LIMESTONE.

Dalmanites dentatus zone. In the Nearpass section the upper cherty members of the New Scotland beds is followed by a series of more or less calcareous shaly beds, at the summit of which are some well-defined beds of limestone filled with fossils. These limestone beds form the crest of the high ridge to the northwest of the Nearpass quarry, and are a southern extension of the beds which form the crest of the ridge in New York

---

*2d Geol Surv. Penn., Rep. G6, pp. 132, 133.

State east of Tri-States, which has been called "Trilobite ridge" by those who have collected in that region. These upper beds are characterized by the great number of trilobite fragments which are preserved in them, the most abundant species being *Dalmanites dentatus.* The trilobite remains are not restricted to the limestone beds at the summit of the formation, but occur also in the more shaly beds below, although they are nowhere so abundant as in the upper beds.

The fauna of these trilobite beds is somewhat peculiar, being a mingling of Lower Helderberg and Oriskany species, and is perhaps equivalent to the fauna from Becraft Mt., in New York, which has been noticed by Beecher and Clarke* and has been referred by them to the lower Oriskany.

The following species have been identified from the trilobite beds in the crest of the high ridge in the Nearpass section:

1. *Vermipora serpuloides* Hall.
2. *Vermipora? tortuosa* Hall.
3. *Orbiculoidea ampla* Hall.
4. *Lingula* sp. undet.
5. *Stropheodonta lincklaeni* Hall.?
6. *Stropheodonta magnifica* Hall.
7. *Stropheodonta* sp. undet.
8. *Chonostrophia* sp. undet.
9. *Chonostrophia complanata* Hall.?
10. *Leptæna rhomboidalis* (Wilck.).
11. *Dalmanella subcarinata* Hall.
12. *Dalmanella perelegans* Hall.
13. *Rhipidomella discus* Hall.
14. *Rhynchonella* several undet. sp.
15. *Rensselæria mutabilis* Hall.
16. *Spirifer arrectus* Hall.
17. *Spirifer* sp. undet.
18. *Cyrtina rostrata* Hall.
19. *Meristella princeps* Hall.
20. *Megambonia bellistriata* Hall? (small form).
21. *Megambonia lamellosa* Hall? (small form).
22. *Modiomorpha?* sp. undet.
23. *Pterinea textilis* (Hall).

---

*Am. Jour. Sci. (3), Vol. XLIV, pp. 410–414.

24. *Pterinea* sp. undet.
25. *Goniophora* sp. undet.
26. *Loxonema* sp. undet.
27. *Strophostylus transversus* Hall?
28. *Capulus* sp. cf. *C. dilatatum* (Hall).
29. *Hyolithes centennialis* Barrett.
30. *Tentaculites acula* Hall.
31. *Tentaculites* sp. undet.
32. *Dalmanites dentatus* Barrett.
33. *Homalonotus vanuxemi* Hall.
34. *Beyrichia* sp. undet.

Aside from the trilobite remains the most abundant and characteristic species of this zone are *Rensselæria mutabilis* and the undetermined species of *Chonostrophia*. The specimens of *Rensselæria* are much larger than those figured by Hall in the Paleontology of New York, volume III, but in volume VIII of the same work larger specimens of the same species have been illustrated which correspond more nearly with the specimens from New Jersey. The species of *Chonostrophia* is probably an undescribed one. It resembles *C. complanata*, but is always smaller and is marked by finer radiating costæ.

These trilobite beds can be traced throughout nearly the entire length of the Walpack ridge in New Jersey, but are less easily distinguished toward the southern part of the region. At Peter's Valley, opposite the residence of Mrs. Coss, the highly fossiliferous calcareous beds at the summit of the formation are well exposed, and the following species have been identified from that locality:

1. *Schizocrania superincreta* Barrett.
2. *Pholidops* sp. undet.
3. *Stropheodonta magnifica* Hall.
4. *Stropheodonta* sp. undet.
5. *Leptæna rhomboidalis* (Wilck.).
6. *Anoplia nucleata* Hall.
7. *Dalmanella subcarinata* Hall.
8. *Chonostrophia* sp. undet.
9. *Rensselæria mutabilis* Hall.
10. *Spirifer arrectus* Hall.

11. *Cyrtina rostrata* Hall.
12. *Meristella princeps* Hall.?
13. *Pterinea textilis* (Hall).
14. *Dalmanites dentatus* Barrett.
15. *Leperditia?* sp. undet.

South of Walpack Center these calcareous beds are again exposed and have afforded the following species of fossils:

1. *Dalmanella subcarinata* Hall.
2. *Rhynchonella* sp. undet.
3. *Rensselaeria mutabilis* Hall.
4. *Megambonia bellistriata* Hall? (small form).
5. *Orthoceras* sp. undet.
6. *Dalmanites dentatus* Barrett.
7. *Homalonotus vanuxemi* Hall.

ORISKANY BEDS.

Spirifer arrectus zone. The Oriskany formation in New Jersey is constituted of two sharply differentiated members, a more or less siliceous limestone which is often somewhat shaly, and a well-defined sandstone. In the northern portion of the district the sandstone is not represented, but near Peter's Valley it makes its first appearance at the top of the formation as a whole, overlying the siliceous limestone beds. The fauna of both the limestone and the sandstone beds is approximately the same, although the fossils in the sandstone are less perfectly preserved and are less abundant.

In the Nearpass section, at a point about one-half mile north of the Nearpass quarry, the following species have been identified from the siliceous limestone:

1. *Stropheodonta magnifica* Hall.
2. *Eatonia peculiaris* (Con.).
3. *Spirifer arrectus* Hall.
4. *Cyrtina rostrata* Hall.
5. *Meristella lata* Hall.
6. *Pterinea textilis* var. *arenaria* (Hall).
7. *Platyostoma ventricosa* Con.
8. *Dalmanites* sp. undet.

On the road leading from Layton to Dingman's Ferry a highly fossiliferous outcrop of the impure, cherty, limestone beds of the Oriskany, is exposed, and has afforded the following species of fossils:

1. *Stropheodonta magnifica* Hall.
2. *Leptæna rhomboidalis* var. *ventricosa* Hall.
3. *Rhipidomella* sp. undet.
4. *Anoplia nucleata* Hall.
5. *Chonostrophia complanata* Hall.
6. *Spirifer arrectus* Hall.
7. *Spirifer arenosus* (Con.).
8. *Cyrtina rostrata* Hall.
9. *Metaplasia pyxidata* Hall.
10. *Anoplotheca flabellites* (Con.).
11. *Meristella lata* Hall.
12. *Pterinea textilis* var. *arenaria* (Hall).
13. *Platyostoma ventricosa* Con.
14. *Dalmanites* sp. undet.

At Peter's Valley, on the hill opposite the residence of Mrs. Coss, weathered masses of the siliceous Oriskany limestone are strewn over the surface, and the hill itself is doubtless constituted of this rock. Some of these loose masses of rock are highly fossiliferous, and the following species have been identified:

1. *Edriocrinus sacculus* Hall.
2. *Stropheodonta magnifica* Hall.
3. *Leptæna rhomboidalis* var. *ventricosa* Hall.
4. *Pholidops ovata* Hall.
5. *Hipparionyx proximus* Van.
6. *Chonostrophia complanata* Hall.
7. *Eatonia peculiaris* (Con.).
8. *Spirifer arrectus* Hall.
9. *Spirifer arenosus* (Con.).
10. *Spirifer tribulis* Hall.
11. *Anoplotheca flabellites* (Con.).
12. *Meristella lata* Hall.
13. *Megambonia bellistriata* Hall.
14. *Platyostoma ventricosa* Con.

15. *Platyceras tortuosum* Hall.
16. *Tentaculites elongatus* Hall.

Near Peter's Valley the sandstone member of the Oriskany formation makes its appearance lying above the siliceous limestone beds, and from this point south its outcrop is more or less continuous. Fossils are poorly preserved in these sandstone beds, but those that have been observed are always identical with species which have been recognized in the calcareous beds below, although not nearly so many species have been collected from the sandstone as from the siliceous limestone beds.

At a locality just below Walpack Center the following species were collected from the Oriskany sandstone:

1. *Leptæna rhomboidalis* var. *ventricosa* Hall.
2. *Spirifer arrectus* Hall.
3. *Anoplotheca flabellites* (Con.).
4. *Meristella lata* Hall.

ESOPUS GRIT.

This is the formation which has usually been known in the past as the "Cauda-galli grit," but for which the members of the New York Geological survey have adopted the name Esopus grit.* It is one of the most persistent formations in the region under discussion, and forms the crest of the Walpack ridge throughout the greater part of its entire length. It is a gray or nearly black gritty rock in which cleavage is frequently developed to a high degree. When the cleavage is not too strongly developed, the fucoid "cauda-galli" markings are frequently abundant along the bedding planes, but other fossils are almost entirely absent, a single specimen of *Lingula* from near Flatbrookville being the only one which has been found.

In the report on Pike and Monroe counties, Pennsylvania, I. C. White† mentions the presence of fossil brachiopods, in this formation, but a careful search in New Jersey has failed to bring to light any other than the one specimen already mentioned. It is possible that the fossils mentioned by White were from the shaly beds at the base of the superjacent Onondaga limestone, as these beds frequently resemble, in a measure, some of the beds of the Esopus grit, and they are usually more or less fossiliferous.

---

*13th Ann. Rep. N. Y. State Geol., Vol. I, p. 209; 47th Rep. N. Y. State Museum, p. 403; Science, N. S., Vol. X, No. 259, pp. 874-878.

†2d Geol. Surv. Penn., Rep. G6, p. 122.

ONONDAGA LIMESTONE.

The Onondaga limestone lies above the Esopus grit, and covers the greater portion of the northwestern slope of the Walpack ridge. Towards its base this formation is somewhat shaly, and sometimes has a slight resemblance to the upper beds of the Esopus slate. These shaly beds, however, soon pass upward into the limestone. The limestone is a hard, regularly bedded rock, the beds ranging from three inches to a foot in thickness. Some of the beds contain large quantities of chert which gives to their weathered surfaces an extremely rough and jagged appearance.

Fossils are not abundant in this formation, and those that are present are usually too firmly imbedded in the matrix to be satisfactorily studied. Along the river road about three and one-half miles below Tri-States, New York, there are several outcropping ledges of this formation from which the following species of fossils were collected:

1. *Stropheodonta* sp. undet.
2. *Atrypa reticularis* (Linn.).
3. *Loxonema* sp. undet.

In a field west of Peter's Valley there are some good exposures of the Onondaga limestone in which some fossils were observed; but aside from numerous corals too firmly imbedded to be collected and some crinoid stems, the only species recognized was *Leptæna rhomboidalis* (Wilck.).

One of the best fossiliferous localities of the Onondaga limestone which has been observed is along the river road about one and one-half miles southwest of Peter's Valley. From this place the following species have been identified:

1. *Stropheodonta perplana* (Con.).
2. *Rhipidomella vanuxemi* Hall.?

3. *Chonetes arcuatus* Hall. ?
4. *Atrypa reticularis* (Linn.)
5. *Reticularia fimbriata* (Con.).
6. *Anoplotheca camilla* (Hall).
7. *Fenestella ?* sp. undet.

Another locality where several species of fossils were secured from the Onondago limestone, is along the river road about four miles above Flatbrookville. From this place the following species have been identified:

1. *Zaphrentis* sp. undet.
2. *Lingula* sp. undet.
3. *Leptæna rhomboidalis* (Wilck.).
4. *Orthothetes pandora* (Bill.).
5. *Spirifer varicosus* Hall. ?
6. *Anoplotheca camilla* (Hall).
7. *Capulus* sp. undet.

Along the river bank about two miles north of Flatbrookville the following species were collected:

1. *Anoplotheca acutiplicata* (Con.).
2. *Orthothetes* sp. undet.

In the shaley beds at the base of the Onondaga limestone fossils are sometimes present, and in the side of the river road about one mile north of Flatbrookville several specimens of *Anoplotheca acutiplicata* were collected from this portion of the formation.

Descriptions of Cambrian Trilobites from New Jersey, with Notes on the Age of the Magnesian Limestone Series.

By STUART WELLER.

Cambrian Trilobites have been recognized in New Jersey at two distinct horizons, (1) in the quartzite near Franklin Furnace, between the crystalline pre-cambrian rocks and the blue magnesian limestones, and (2) in the blue magnesian limestone at Carpentersville on the Delaware river about six miles below Phillipsburg.

In the first of these localities, trilobites belonging to the genus *Olenellus* occur in an exceedingly hard, bluish, calcareo-siliceous bed, which has been traced by its weathered fragments on the surface, from Hardistonville on the north to some distance south of Franklin Furnace. This same bed has been noticed again north of Andover. The actual thickness of this fossiliferous bed has not been observed, but it cannot be more than a very few feet. The trilobites can be recognized only in the weathered portion of the rock, from which the calcareous matter has been dissolved. This weathered rock is of a deep brown color, arenaceous and friable, and it splits along the planes where the trilobite tests have been removed by solution during the process of weathering. A careful search in the fresh, unaffected portion of the rock failed to disclose any sign of fossil remains, but that they are really present in abundance is shown by their frequency in the weathered portions.

The Hardistonville Quartzite, as it has been named by Wolff and Brooks* in the region of Franklin Furnace, has been known to contain the remains of trilobites of the genus *Olenellus*, for some time. They were first discovered by Beecher,† who made an examination of the rocks for fossils in connection with Nason's studies of the white crystalline limestone at Franklin Furnace. Later, Foerste* found numerous fossil localities during his studies with Wolff, for the United States Geological Survey. The accompanying illustrations, however, are the first figures that have been published of these New Jersey specimens of *Olenellus.*

---

*18th Ann. Rep. U. S. G. S., Pt. II, p. 442.

†Ann. Rep. State Geol. N. J. for 1890, p. 49.

The second locality, in the magnesian limestone at Carpentersville, has not hitherto been recognized; in fact, no trilobites have previously been recorded from this magnesian limestone series in New Jersey. The locality where the fossils occur is in Robinson Brothers' quarry south of the village of Carpentersville. In this quarry the strata dip to the northwest at an angle of from 65° to 70°, with the strike N. 60° E. Most of the fossils were found in the quarried stone at the north end of the quarry, but a careful search located the fossils *in situ* in the upper part of the north end of the quarry, in a bed which, if continued, would pass about ten or twelve feet north of the northernmost of the three kilns by the railroad track. The specimens are apparently all of a single, small and somewhat variable species which is referred to the somewhat doubtfully valid genus *Liostracus.* The only other American species which have been placed in this genus have been described from the middle Cambrian of New Brunswick, and although the species from Carpentersville is not closely allied to any of those previously recognized, it will perhaps be safe to refer the beds containing it to the middle Cambrian.

The Hardistonville quartzite, with its Olenellus fauna, is referable to the lower Cambrian, and similar quartzite having the same position between the magnesian limestone and the crystalline rocks occurs at frequent intervals and is perhaps continuous throughout the whole length of the paleozoic area in New Jersey. Below Carpentersville no actual outcrop of this quartzite was observed between the fossil locality in the magnesian limestone and the crystalline rocks; it may be present, however, covered with drift. The actual position of the fossil bearing bed at Carpentersville, within the limestone series, was not definitely fixed, although it is probably somewhere in the lower third of the entire series.

---

*Am. Jour. Sci. (3) vol. XLVI, p. 438.

If the lower portion of the magnesian limestone series be middle Cambrian, as the fossils seem to indicate, the age of the higher beds still remains to be determined. Lying on top of the magnesian limestones at many localities in New Jersey is a thin bed of highly fossiliferous limestone, free from magnesia, whose age as indicated by the fossils is Trenton. This fixes the age of the uppermost magnesian limestone beds as at least pre-Trenton. This Trenton limestone has usually been considered as directly continuous with the subjacent beds, but there is always present in the basal portion of the formation, where it can be observed, a conglomerate bed in which the pebbles are of the subjacent magnesian limestone and the matrix is the purer Trenton limestone. This conglomerate bed is best exposed east of Branchville, but it was also noticed near Belvidere, near Andover, and near Newton. The presence of this conglomerate bed at the base of the Trenton limestone, indicates that there must have been a time hiatus between the deposition of the magnesian and the Trenton limestones. In order to determine the length of this time interval it will be necessary to secure fossils from the uppermost beds of the magnesian limestone. Until such evidence can be secured, however, considering the fact that the only fossils as yet found in the magnesian limestone are of Cambrian age, it seems best to consider the entire series as Cambrian, allowing the lower Ordovician time to be represented by the time interval which elapsed between the deposition of the magnesian and the Trenton limestones. This interpretation must be held as a tentative one, however, subject to corroboration by the discovery of Cambrian fossils in the upper strata of the magnesian limestone.

DESCRIPTION OF SPECIES.

Olenellus thompsoni (Hall)?

(Plate I, Figs. 9-10.)

Head, without the genal spines, subsemicircular in outline. Glabella elongate with subparallel sides, depressed convex, marked by four pairs of furrows of which the anterior pair is situated about two-fifths the length of the glabella from the anterior end and the others arranged about equidistant from each other, the posterior pair usually the most pronounced. The eye-lobes level with the glabella and separated from it by rather broad furrows, their anterior extremities opposite the anterior pair of glabella furrows. Eyes elongate, reaching nearly to the posterior margin of the head, narrowly crescentic in outline. Cheeks sloping away from the glabella and eyes to the lateral and anterior margins, with a gentle convexity at first, but becoming slightly concave near the margin. The margins bordered by a narrow, scarcely elevated rim. The head alone of this species has been observed in New Jersey.

REMARKS.—For a complete discussion of the members of this genus, with bibliography, reference is made to Walcott's Bulletin No. 30, U. S. Geological Survey, and to the 10th Annual Report of the U. S. Geological Survey.

From the head alone it is difficult to identify the species of this genus with entire certainty, but the New Jersey specimens seem to agree most closely with the typical species of the genus, *Olenellus thompsoni*. All the species of *Olenellus* and the allied genera or subgenera *Holmia* and *Mesonacis*, are remarkable because of the apparent absence of facial sutures upon the dorsal side of the head. This characteristic is well shown in the New Jersey specimens. The heads are either complete as in Fig. 10, with no indication whatever of facial sutures, or if the outer portions of the cheeks are detached they are always broken along irregular lines as in Fig. 9, being very different in this respect from trilobites in general, whose detached cheeks are separated from the cranidium along definite lines. Holmes' study of the Scandinavian species, *O.* (*Holmia*) *kjerulfi*, indicates that that species does possess a true facial suture along the doublure on the ventral side of the head. Beecher* has recently made the character of a marginal or ventral facial suture the chief characteristic of the order Hypoparia in his admirable classification of the trilobites, and *Olenellus* and its allies should, on this basis, be included in this order rather than in the order

---

*Am. Jour Sci. (4), Vol. III, p. 183.

Opisthoparia, in the same family with *Paradoxides.* Walcott* suggests a family separation of *Olenellus* and its allies from *Paradoxides* under the family name Mesonacidiæ, but the separation seems to be of even more than family importance. If the Mesonacidiæ be considered as a family of the Hypoparia they differ conspicuously from other members of that order in the remarkable development of their eyes, but these eyes of *Olenellus*, under this interpretation, cannot be considered as analogous to the eyes of other trilobites, which are always borne upon the free cheeks.

Liostracus? jerseyensis n. sp.

(Plate I, Figs. 1-8.)

Species known by the cranidium and pygidium alone. Cranidium, exclusive of the lateral angular extensions of the posterior margin, and the posterior spine of the occipital ring, longitudinally semi-ellipitical in outline. Glabella large and prominent, longer than wide, sub-quadrangular or sub-elliptical in outline, marked by two pairs of faint furrows, of which the anterior pair are transverse in their direction, each one extending to about one-third the width of the glabella, sometimes nearly or quite obsolete; the posterior pair always present, although sometimes nearly obsolete, arching backwards towards the occipital furrow. Occipital ring separated from the glabella by a deep and rather wide occipital furrow, extended posteriorly in a broadly triangular spine which is slightly attenuate towards the extremity. Fixed cheeks somewhat convex, bending downward to the lateral margins; the anterior margin of the head bending upward and forming a rather conspicuous elevated rim in front. Facial sutures slightly curved inward anteriorly and bending outward posteriorly to the posterior margin, their direction being somewhat sigmoidal. No free cheeks have been recognized and the position of the eyes is not definitely shown on the margin of the fixed cheeks, but they are apparently nearly opposite the anterior furrows of the glabella.

Pygidium small, much broader than long, obtusely subangular at the posterior extremity; axis prominent and strongly convex, consisting of five segments, with indications of a sixth

---

* 10th Ann. Rep. U. S. G. S., p. 635.

one posteriorly, its posterior extremity abruptly rounded and reaching to the posterior margin of the pygidium; pluræ nearly flat, with a slight marginal groove, consisting of five segments.

REMARKS.—The genus *Liostracus* is closely allied to *Ptychoparia*, and has not always been considered as distinct by American paleontologists. In his list of paleozoic fossils Miller* records the following six species of the genus, besides four varieties: *L. aurora* Hartt, *L. linnarsoni* Brög., *L. neglectus* Hartt, *L. onongondianus* Hartt, *L. quadratus* Hartt, and *L. tener* Hartt, all from the Cambrian strata of New Brunswick. Walcott† refers all these species except *linnarsoni*, which he does not notice, to the genus *Ptychoparia*. Matthew,‡ in his studies of the New Brunswick Cambrian faunas, refers *linnarsoni* to *Ptychoparia*, but retains *onongondianus* and *tener* in the genus *Liostracus*, the chief generic characters recognized being the absence of genal spines, the faint glabella furrows, and the small number of segments in the pygidium. If the genus *Liostracus*, based upon the characters enumerated by Matthew, is really valid, then the New Jersey specimens here described should probably be included in it. The presence or absence of genal spines, however, cannot be determined because the free cheeks have not been observed, but the faintness of the glabella furrows is a conspicuous character in all the specimens, and the pygidium contains but few segments.

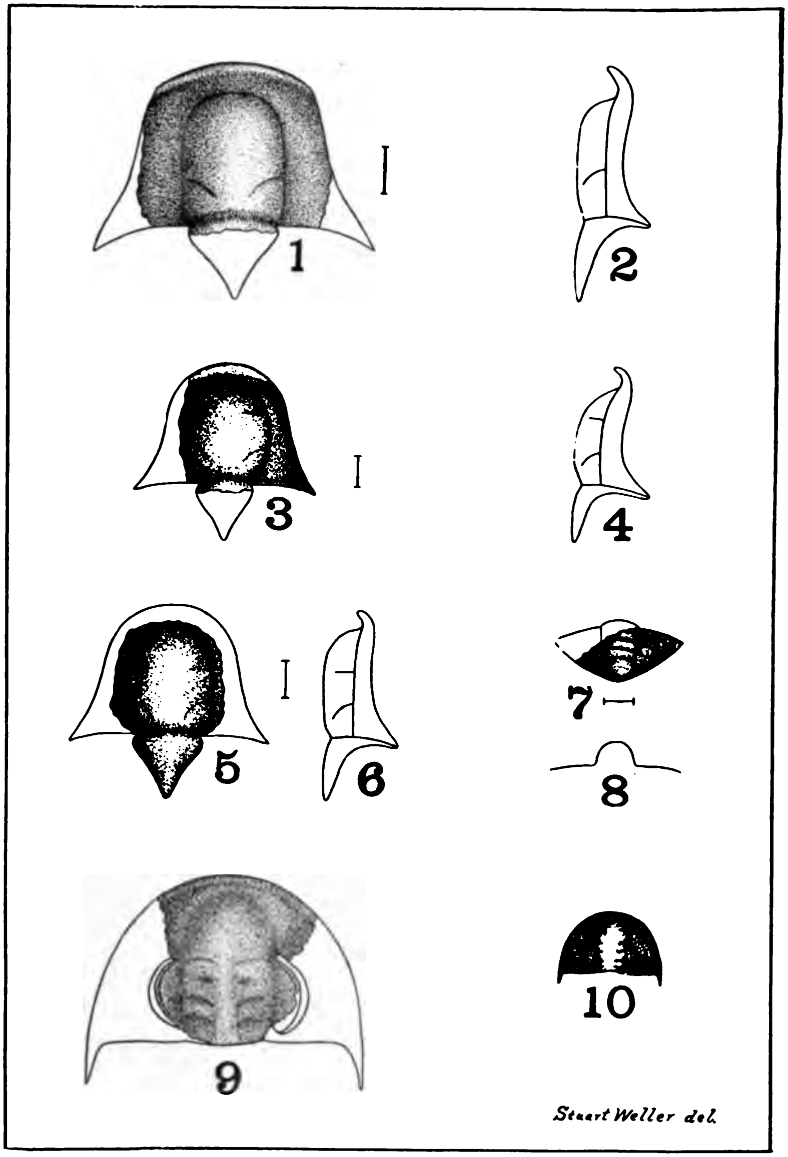
The specimens referred to this species exhibit considerable variation, especially in the form of the glabella, as is indicated by the accompanying figures, but they do not seem to represent distinct species.

---

*North Am. Geol. and Pal., p. 555.

†Bull. U. S. Geol. Surv., No. 10.

‡Trans. Roy. Soc. Can., 1887, pp. 133-152.



Cambrian Trilobites.

Explanation of Plate I.

Figs. 1–8. *Liostracus? jerseyensis* n. sp. All enlarged 5 diameters.

Figs. 1–2. Dorsal view and profile in outline, of the largest specimen observed, showing the subquadrangular glabella and the obsolete anterior glabella furrows.

Figs. 3–4. Dorsal view and profile in outline, of a smaller specimen with elliptical glabella and one entire fixed cheek.

Figs. 5–6. Dorsal view and profile in outline, of a specimen retaining the spine of the occipital ring.

Figs. 7–8. Dorsal view and cross-section of a pygidium.

Figs. 9–10. *Olenellus thompsoni* (Hall)? Natural size.

Fig. 9. Imperfect head of the largest individual observed.

Fig. 10. A perfect head of average dimensions.

PART II.

Artesian Wells

By LEWIS WOOLMAN.

Artesian Wells.

OUTLINE.

INTRODUCTION.

I. Wells in Southern New Jersey.

Sec. 1.—Wells in Cretaceous Strata.

At Hancock's Bridge.
At Pennsville. Two wells.
At Perkintown Station. One mile east of.
At Perkintown Station. One and one half miles east of.
At Pedricktown.
At Mickleton. Four miles west of.
At Mickleton. Northeast of.
At Laurel Springs.
At Westville.
At Camden. 17th and Stevens streets.
At Pensauken.
At Colestown.
At Marlton. Northeast of.
At Marlton. Southeast of.
At Milford.
At Riverton.
At Burlington. Three wells.
At Smithville.
At Columbus.
At Lakewood. Two wells.
At West Asbury Park.
At Seabright
At Port Monmouth.
At Rumson Bluff.
At Little Silver.
At Babylon, N. Y.
At Woodside, N. Y.
At Kennedyville, Md.
At Centreville, Md.
At Chesapeake Beach, Md.

At Tilghman's Island, Md. At Taylor's Island, Md.	These two wells may draw from horizons above the Cretaceous, the one at Taylor's Island possibly above the Eocene.

At Norfolk, Va. Lambert's Point, north of.
At Norfolk, Va. Moore's Bridges, east of.
At Severn River, Va.

Sec. 2.—Wells in Miocene Strata.

At Bridgeton.
At Cedarville.
At Greenbank.
At Smith's Landing. County Asylum
At Atlantic City :
    At the Traymore.
    At the Waldorf-Astoria.
    At the Gas Works.
At Ocean City.
At Sea Isle City.
At Mahon River, Del.
At Bowers Beach, Del.
At Madison, Md.
At Delmar, Md.
At Salisbury, Md.
At Pokomoke City, Md. Two records.

Sec. 3.—Wells in Post Miocene, or Surface Strata.

Philadelphia Navy Yard, Pa.
Northfield.
Absecon.
Atlantic City.
Shinnecock Hills, L. I., N. Y.
Sciasconsett, Nantucket Island, Mass.
Laurel, Del.
Seaford, Del.

II. Wells in Northern New Jersey.

Sec. 1.—Bored Wells reported by Stotthoff Bros.

At Huntsville. Two wells.
At Sparta.
At Bernardsville. Three wells.

At Flemington. Two wells.
At Readington.
At Three Bridges.
At Liberty Corners.
At Somerville.
At Goodman's Crossing.
At Maywood. Two wells.
At Trenton.
At Martinsville.
At Union.
At Linden.
At Elizabeth.
At Passaic. Five wells.
At New Dorp, Staten Island, N. Y. Two wells.
At Burdette, N. Y.
At Woodside Long Island N Y.
At Whitestone, Long Island, N. Y.
At Fairfield, Conn.
At Easton, Pa.
At Bethlehem, Pa.
At Rose Glen, Pa.
At Seigfried, Pa.
At Yardley, Pa. Two wells

Sec. 2.—Bored Wells reported by P. H. & J. Conlan.

At and near Summit. Two locations.
At Newark. Two wells.
At Harrison.
At Kearney.
At West Orange.
At and near Passaic. Five locations
At Pompton.
At Rahway.
At Jersey City.
On Shooter's Island.
In New York City.
At Rockaway, L. I., N. Y

Sec. 3.—Wells reported by The Joseph Dixon Crucible Co.

At Jersey City. Two wells.

ARTESIAN WELLS.

INTRODUCTION.

We present for this year records and geological data respecting well borings, first in Southern New Jersey and then in Northern New Jersey. With the former we also include some wells at a few points beyond the State, both to the east and to the south. The wells beyond the State are introduced because of the correlation of the beds penetrated by them with the same beds beneath the Southern New Jersey coastal plain.

I. Wells in Southern New Jersey.

The records of wells in Southern New Jersey naturally fall into three heads, under which we treat them in the succeeding pages, viz.:

1. Wells drawing water-supply from Cretaceous strata.
2. Wells drawing water-supply from Miocene strata.
3. Wells drawing watef-supply from Post-Miocene or surface strata.

The wells noted to the eastward of the State are on Long Island, with one exception (a well on Nantucket Island), and those to the southward are, with the exception of two wells near Norfolk, Va., on the Delaware–Maryland peninsula, which intervenes between the Delaware and the Chesapeake bays.

The strata penetrated by the wells to the eastward and southward are, in either direction, more or less identical with, and the continuation of, some of the beds on the coastal-plain portion of New Jersey. The data are of value in correlating the various geological subdivisions and their interbedded water-yielding horizons.

Sec. 1.—Wells in Cretaceous Strata.

ARTESIAN WELL AT HANCOCK'S BRIDGE, AT FOGG & HIRES' CANNING FACTORY.

Elevation, 5 (?) feet; diameter, 4½ inches; depth, 58 feet.
Water rises within 5 feet of the surface

Haines Bros. furnish the following record of strata penetrated in a well bored by them at the above location:

Made ground,	5 feet	= 5 feet.
Grayish-white sand,	47 "	= 52 "
Shells, "6 inches," say,	½ foot.	
Sand,	1½ feet	= 54 "
Shells, "10 inches," say,	1 foot	= 55 "
Sand, say,	2 feet	= 57 "
Shells, "12 inches," say,	1 foot	= 58 "

This well was cased to the depth of 52 feet and required no casing below that depth. "An elegant supply of good water" was obtained.

We have included this among Cretaceous wells, but it may possibly draw from a somewhat higher horizon. We are not informed as to the character of the shells noted in the three separate but very close layers near the bottom. If the species were known they would doubtless determine the geological position of the beds.

TWO ARTESIAN WELLS AT PENNSVILLE.

Elevation, 10 feet; diameter of each, 3 inches; depth of each, 33 feet.
Water rises in each well to within 8 feet of the surface.
The water in both wells rises and falls 8 inches with the tides.

At Pennsville, also for Fogg & Hires, Haines Bros. have bored a well to the depth of 33 feet, of which they furnish this record:

Clay,	10 feet	= 10 feet.
Grayish sand,	23 "	= 33 "

At the same place and for the same firm, Haines Bros. have also bored to the same depth (33 feet) a second well, this time on land where quite recently the river flowed, that is, since the settlement of the region by the white man. In this well the material is described as "sand all the way down."

In both these wells Haines Bros. note that "the water rises to within eight feet of the surface and also rises and falls *eight* inches with the tides."

These wells are evidently supplied with filtered river water.

ARTESIAN WELL, ONE AND ONE-HALF MILES EAST OF PERKINTOWN STATION, DELAWARE RIVER R. R.

Elevation, 15 (?) feet; diameter, 3 inches; depth, 115 feet.
Water rises to within 14 feet of the surface.

From Haines Bros. we have learned the following respecting a well bored by them for Thomas Berry, on a farm between Auburn and Perkintown Station, the last-named place being on the Delaware River Railroad. The well has a depth of 115 feet and passed through the following strata:

Clay,	**8 feet**	**= 8 feet.**	
Marl,	**37 "**	**= 45 "**	**? Matawan**
Black sand mixed with slimy marl,	**45 "**	**= 90 "**	
Fine gray sand,	**20 "**	**= 110 "**	
Coarse sand,	**5 "**	**= 115 "**	

The water is "clear but irony and there is plenty of it." This well was pumped 1,000 gallons per hour. The supply is probably from the base of the Woodbury–Wenonah water-horizon, as defined in the Annual Report for 1898 and as shown on the Artesian Well Section, Plate III, of that report.

ARTESIAN WELL, ONE MILE EAST OF PERKINTOWN STATION.

Elevation, 10 feet; diameter, 3 inches; depth, 41 feet.
Water rises to within 8 feet of the surface.

Haines Bros. have also drilled a well for George Gaventa about one-half mile west of the last well reported herein, and about one mile east of Perkintown Station. This well was bored to the depth of only 41 feet. Haines Bros. say the material passed through was "pure white sand all the way to the bottom, where the sand was mixed with coarser sand and gravel," in which some of the pebbles are described as being as large as hens' eggs.

This well furnishes "plenty of clear water" and was tested by pumping 1,200 gallons per hour. The supply may possibly be from the Woodbury-Wenonah water-horizon.

ARTESIAN WELL, THREE-FOURTHS OF A MILE SOUTHEAST OF PEDRICKTOWN.

Elevation, 30 feet; diameter, 2 inches; depth 180 feet.
Water rises to within 30 feet of the surface.

Haines Bros. have furnished the following data, which we copy verbatim, respecting a well bored by them for Ebenezer Sparks at a point about three-fourths of a mile southeast of Pedricktown.

Soil, sand and loam,	2 feet	= 2 feet.	
Blue clay,	4 "	= 6 "	Age ?
Marl,	39 "	= 45 "	Matawan.
Iron-stone, 3 inches,			Raritan.
Gray sand,	8 "	= 53 "	
Sand with white plastic clay,	29 "	= 82 "	
Plastic clay,	20 "	= 102 "	
Sand, water-bearing,	10 "	= 112 "	

The water-supply is just below the base of the clay marl or Matawan division and from the upper part of the plastic clay or Raritan division of the Cretaceous.

Subsequently to the receipt of the above record we have learned that this well was afterward deepened to 180 feet, increasing the amount of water supplied. We are not informed as to character or succession of the material below 112 feet, but the continuation was doubtless within the Raritan beds.

ARTESIAN WELL FOUR MILES WEST OF MICKLETON.

Elevation, 15 (?) feet; diameter, 3 inches; depth, 43 feet
Water rises within 14 feet of the surface.

From Haines Bros. we have obtained the following information respecting a well bored by them for E. G. Miller, on a farm located between Asbury Station and Gibbstown and about four miles west of Mickleton.

Soil,	2 feet	= 2 feet	
Clay,	6 "	= 8 "	Matawan.
Marl,	12 "	= 20 "	
Fine gray sand,	15 "	= 35 "	
Coarse sand,	8 "	= 43 "	

This well was cased to the bottom. The water rises within 14 feet of the surface and is "soft and good." The well was pumped for two days at the rate of 1,200 gallons every hour. The supply is probably drawn from the Woodbury–Wenonah water-horizon.

ARTESIAN WELL, ONE-HALF MILE NORTHEAST OF MICKLETON.

Elevation, 50 feet; diameter, 3 inches; depth, 183 feet
Water rises within 45 feet of the surface.

For Howard Busby, of Philadelphia, Haines Bros. have bored a well, located as noted above, to the depth of 183 feet. Of this they have furnished the following description of strata, which we quote verbatim:

Loam,	3 feet,	= 3 feet.	
Clay,	15 "	= 18 "	
Black marl,	20 "	= 38 "	Matawan Clay Marls.
Black sand, mixed with slime,	20 "	= 58 "	
Running marl,	115 "	= 173 "	
White sand with water,	10 "	= 183 "	

We are informed that "the water rises within 45 feet of the surface," also that it "is soft," and that "there is plenty of it." The source of supply is probably in the Woodbury-Wenonah water-horizon.

ARTESIAN WELL AT LAUREL SPRINGS.

Elevation 80 (?) feet; diameter, 3 inches; depth, 48 feet.
Water rises within 18 feet of the surface.

A well has been put down by A. G. Dunphey for Col. John A. Wiedersheim near Laurel Springs Station, on the Reading Railroad Company's route to Atlantic City.

The well was finished at the depth of 48 feet. The water rises to within about 18 feet of the surface, which has an elevation of about 80 feet.

The water-bearing stratum in which the boring stopped is described as a "pepper-and-salt sand."

ARTESIAN WELL AT WESTVILLE.

Elevation, 14 feet; diameter, 6 inches; depth. 241 feet
Water rises within 11 feet of the surface.

In the Annual Report for 1897, page 268, there are noted two wells at this locality, put down to supply the town with water; their depths are respectively 112 and 114 feet. The well now under notice was put down the present year, adjacent to the two former wells, for the supply of the same water-plant, but to a lower horizon.

The former wells (1897) draw from an horizon at the base of the Matawan clay marls; this well draws from a still lower stratum which is quite within the upper portion of the Raritan formation.

Through the courteous co-operation of the American Pipe Co., contractors for the water-plant, and of Jos. W. Pratt, the well-driller, we have been furnished with an unusually liberal supply of the borings, at frequent intervals, from which we compile the following record:

Surface soil,	0	feet	to	2	feet	Pensauken.
Coarse yellow gravel with large pebbles,	2	"	"	22	"	
Black clay.	22	"	"	46	"	Matawan.
Bluish-white coarse gravel,	46	"	"	60	"	
Mixture of coarse gravel and fine sand, bluish-white in shade.	60	"	"	75	"	
Mixture of clay, coarse gravel and very large pebbles,	5	"	"	113	"	
Mixture of fine sand and very coarse gravel, with large pebbles and cobbles, containing a clay streak at 129 feet. *First Water-Horizon*.	113	"	"	155	"	

Streak of sticky red plastic clay, at . .	155 feet.	Raritan
Mixture of fine sand, coarse gravel, with a little clay, the whole yellowish-white in color, ...	155 feet to 170 "	
Solid bed of red, sandy. plastic clay, . .	170 " " 217 "	
Decidedly white, coarse gravel, water-bearing. *Second Water-Horizon*, . .	217 " " 228 "	
Red clay, ...	228 " " 231 "	
Sand, ...	231 " " 241 "	

An abundance of water was had in this lower sand, but it was found impracticable to free it from the red color contributed by the red clay, and the well was therefore not put into use.

ARTESIAN WELL IN CAMDEN AT SEVENTEENTH AND STEVENS STREETS.

Depth, 81 feet.
Water rises to within 3 feet 6 inches of the surface
Was pumped 250 gallons a minute.

Hon. George Pfeiffer, through W. H. Boardman, C. E., furnishes the following record of a well put down by him at the Keystone Morocco Works, at Seventeenth and Stevens streets, East Camden:

Thickness of Strata.		Intervals of Depth.
3 feet.	Surface sand, ...	0 to 3 feet.
4 "	Sand, ...	3 " 7 "
4 "	Coarse sand, ...	7 " 11 "
3 "	" "	11 " 14 "
6 "	Dark "	14 " 20 "
4 "	Coarse, dirty sand, ...	20 " 24 "
3 "	Very coarse sand, ...	24 " 27 "
4 "	" " gravel, ...	27 " 31 "
8 "	Light-yellow clay, ...	31 " 39 "
2 "	Fine clayey sand, ...	39 " 41 "
18 "	Red plastic clay, ...	41 " 59 "
2 "	Red and white clay, ...	59 " 61 "
3 "	Fine sand, ...	61 " 64 "
6 "	Fine white sand, ...	64 " 70 "
3 "	Coarse white sand, ...	70 " 73 "
8 "	Coarse, clean, white sand, ...	73 " 81 "
	Black clay at	81 "

This well was finished with an eighteen-foot strainer, whose base rests at the depth of 81 feet. "The well was pumped 250 gallons a minute on 18-foot draft."

ARTESIAN WELL NEAR PENSAUKEN.

Elevation, 40 feet; diameter, 4 inches; depth, 102 feet.
Water rises within about 41 feet of the surface.

A four-inch artesian well has been put down for John Collins by A. G. Dunphey, near Pensauken station, northeast of Merchantville. The locality has an elevation of about forty feet and the well a depth of 102 feet. The well is nearly on the line of strike (northeast and southwest) with the wells at Jordantown, which supply Merchantville with water and which are about one mile to the northeast. This well and those at Jordantown both draw from the Raritan group of water-horizons, but from higher beds within that formation than are utilized by the wells at Morris Station for the supply of Camden. In the sinking of the wells at Jordantown, two water-horizons were encountered, viz., at 58 to 78 feet, and at 128 to 140 feet, but the upper one was there cased off and only the lower one used. The well at Pensauken, however, was not prospected so far as the lower horizon, but was finished in the upper one.

At the locality of this well, as likewise at the locality of the Jordantown wells, the clay marls are absent, although a short distance to the eastward they overlie the Raritan formation. In both cases the quality of the water is said to be excellent, and is so probably because of this fact. The water obtained from many of the beds within the Matawan clay marls is apt to be "irony", probably from the presence in these clays of iron pyrites. The contamination from this source seems to be sometimes contributed by seepage therefrom into the upper portion of the underlying Raritan beds.

From an excellent series of samples furnished by A. G. Dunphey, and taken every two or three feet as the drilling progressed we are able to report the following record of strata:

Orange-yellow sand, with a streak of iron stone at 8 feet, and a second streak of iron stone at 38 feet,	0 feet	to	38 feet.	Pensauken.
Yellow gravel and sand with large pebbles,	38	" "	53 "	Raritan.
White gravel, large pebbles,	53	" "	75 "	
White fine sandy clay,	75	" "	83 "	
Fine yellowish white *water-bearing* sand,	83	" "	102 "	

ARTESIAN WELL NEAR COLESTOWN.

Elevation, 40 feet ; diameter, 3 inches ; depth, 347 feet.
Water rises within 24 feet of the surface.

W. C. Barr has put down a well on the farm of the Sharpless Brothers, near Colestown, of which he has furnished the following record :

Top soil and greenish clay,	6 feet	= 6 feet.		
Greenish-gray quicksand,	12 "	= 18 "		
Black clay,	100 "	= 118 "	Matawan	Cretaceous
Green clay,	20 "	= 138 "		
Black clay,	12 "	= 150 "		
Green clay,	10 "	= 160 "		
Water bearing loamy sand,	1 "	= 161 "		
Chocolate clay stratum, 4 inches thick				
White sand and gravel with "irony" water,	130 "	= 291 "		
White clay,	5 "	= 296 "	Raritan.	
Coarse white sand with "irony" water,	10 "	= 306 "		
White clay,	8 "	= 314 "		
Fine white sand,	6 "	= 320 "		
Red clay,	10 "	= 330 "		
Coarse sand with unsatisfactory water,	6 "	= 336 "		
White clay,	2 "	= 338 "		
White sand with wood (lignite),	7 "	= 345 "		
White clay and large boulders,	2 "	= 347 "		

This well has not yet been finished. Excepting the water from the one-foot stratum at 160 feet, which is said to be good, all the water found proves quite "irony" and unsatisfactory.

ARTESIAN WELL, TWO AND ONE-HALF MILES NORTHEAST OF MARLTON.

Elevation, 65 feet ; diameter, 3 inches ; depth, 60 feet
Water rises within 7 feet of the surface.

A. G. Dunphey has bored a well on the property of Jacob L. Evans, situated on the road from Evesboro to Medford at point about two and one-half miles slightly north of east from Marlton. The well has a depth of 60 feet. It is about one-fourth of a mile northwest of a bored well on the farm of Josiah Ballenger, on ground a few feet higher, and which has a depth of 76 feet, as noted in the Annual Report of 1894, page 210.

From specimens of the borings we make the following record:

Iron rusty, sandy clay, from near the surface to	**7 feet.**
Greensand marl light green in color, ...	**7 feet to 50 "**
Greensand, dark, olive green, ...	**50 " " 54 "**
Olive-colored sand, with comminuted shell, ...	**54 " " 58 "**
Belemnites at 58 feet.	
Water-bearing sand.	**58 " " 60 "**

The water rises within seven feet of the surface, the supply coming from the Marlton water-horizon, as designated in former annual reports. This horizon furnishes most of the wells in the region about Marlton. The well for the town supply, however, taps a lower water-bearing bed, viz., the Cropwell horizon, which is about 100 or 110 feet deeper.

ARTESIAN WELL TWO MILES SOUTHEAST OF MARLTON.

Elevation, 65 feet ; diameter, 3 inches ; depth, 83 feet.
Water rises within 9 feet of the surface.

A. J. Dunphey has put down a well for Joseph K. Evans at a point about two miles southeast of Marlton and about one-half mile south of a well at the residence of the late Benjamin Cooper. The well has a depth of eighty-three feet. This boring was discontinued in sand immediately under a stratum containing *belemnites*, which occurs at and marks the division between the base of the marl series and the top of the Matawan clay marls. No specimens were preserved, but the record of strata would doubtless be the same as has already been noted in past annual reports for other wells near by.

ARTESIAN WELL AT MILFORD.

Elevation. 90 feet ; diameter. 3 inches ; depth. 58 feet.
Water rises within 6 feet of the surface

A well has been put down for Adam Olt at Milford. From A. G. Dunphey, who bored it, we have received specimens of the borings, from which we make the following record:

Surface soil,	0 feet to	4 feet.
Orange-yellow gravel,	4 "	" 7 "
Fine light yellow sand,	7 "	" 14 "
Dark micaceous clay,	14 "	" 40 "
Olive-colored sand, containing some greensand (glauconite),	40 "	" 50 "
Lime-sand, contains *Bryozoa*, also *Echinus* plates and spines,	50 "	" 56 "
Gray sand, consisting of white quartz and greensand grains, resembles a mixture of pepper and salt, *water-bearing*,	56 "	" 58 "

This well is supplied from the Lindenwold water-horizon, which is interbedded within the limestone layers above the middle marl.

ARTESIAN WELL, ONE AND ONE-HALF MILES EAST OF RIVERTON.

Elevation, 80 feet ; depth, 117 feet.
Water rises within 69 feet of the surface.

This well was put down by A. G. Dunphey, who furnishes by letter the data tabulated above. He further says the well was finished at the base with a ten-foot strainer and has been pumped 15 gallons a minute without lowering the natural level of the water. He also states that the water was found in a "fine free white gravel and sand mixture."

TWO BORED WELLS AT BURLINGTON FOR H. F. POTTER, TO SUPPLY AN ICE PLANT.

Depths, 58 and 71 feet.

These wells were bored by Stotthoff Bros., who furnish the following record:

Record.	Well No, 1.	Well No. 2.
Earth,	6 feet.	6 feet.
Gray quicksand,	37 "	50 "
Coarse gray sand, with water,	15 "	15 "
	58 "	71 "

Well No. 1 produces 18 gallons a minute, and Well No. 2 60 gallons a minute. These wells are 100 feet apart, but are on ground of the same level.

ARTESIAN BORING AT EAST BURLINGTON.

Elevation, 10 feet; depth, 95 feet.

Hon. George Pfeiffer, contractor, made a well-boring near the railroad station at East Burlington, N. J., the purpose being to find a water-supply for the intended plant of a prospective ice manufacturing company. The well was not completed, however, as the enterprise was abandoned. The following accurate record of strata penetrated, furnished by Wm. H. Boardman, C. E., is interesting and valuable:

Thickness of strata.		Intervals of depths.
6 feet	top soil,	0 to 6 feet.
13 "	clayey gravel,	6 " 19 "
6 "	coarse gravel,	19 " 25 "
7 "	coarse red sand,	25 ' 32 "
4 "	fine red sand,	32 " 36 "
14 "	coarse white sand,	36 " 50 "
12 "	fine dark sand,	50 " 62 "
5 "	stiff gray clay,	62 " 67 "
18 "	stiff red clay,	67 " 85 "
5 "	sandy gray clay,	85 " 90 "
4 "	slush gray sand, very little water,	90 " 94 "
1 foot	soft [disintegrated] micaceous rock,	94 " 95 "

ARTESIAN WELL NO. 2, AT SMITHVILLE.

Elevation, 20 feet; diameter, 6 (?) inches; depth, 110 feet.

This is the second well put down at this place for the H. B. Smith Machine Company. The former one was noted in the Annual Report for 1897, page 278. The present well, as also the former one, was drilled by W. C. Barr, who furnishes the subjoined record of this one, which he states differs from the previous well in the occurrence, near the top, of an 8-foot bed of gray sand similar to that of the first water-bearing sand at Marlton, which, indeed, it probably represents, and which had evidently been eroded from the place where the other well was put down, although the wells are probably not more than 100 feet apart. The location of these wells is on the flood plain of Rancocas creek.

Made ground,	10	feet =	10	feet.
Gray sand, same as in the first water-horizon at Marlton,	8	" =	18	"
Black clay,	2	" =	20	"
Green quicksand,	35	" =	55	"
Black clay,	55	" =	110	"
Water-bearing sand at			110	"

At the base of this well, as also in the former well, there were found fragments of fossil bone, probably representing some extinct Cretaceous reptile. Some teeth also, probably reptilian, were obtained at the same horizon in the first well.

ARTESIAN WELL AT COLUMBUS.

Elevation, 70 feet; diameter, 4 inches; depth 225 feet.
Water rises to within 60 feet of the surface.

An artesian well with a depth of 225 feet has been put down the past summer at Columbus. The work was done for the Columbus Water Company, by A. G. Dunphey, from whom we have received samples of the borings. From these specimens and from information verbally received from several of the directors, also from Edgar A. Alcott, C. E., and from A. G. Dunphey, we have computed the following record:

Soil,	2 feet,	= 2 feet.	
Orange-yellow sand and gravel,	8 "	= 10 "	
Orange-yellow sand, light in shade,	18 "	= 28 "	
Gray sand,	2 "	= 30 "	Matawan. Cretaceous.
Black clay with coarse sand,	2 "	= 32 "	
Flat stone concretion at		32 "	
Olive-colored sandy clay,	14 "	= 46 "	
Bluish or black clay, Greenish, marly clay, with glauconite,	74	= 120 "	
Bluish clay,	76 "	= 196 "	
Bluish-white sand, with lignite, water-bearing,	29 "	= 225 "	

This well was finished at the bottom with a Cook strainer twenty feet in length. This strainer or sieve consists of a brass tube with fine horizontal slits, about one-fourth of an inch apart, which are arranged around its circumference in parallel perpendicular rows.

The water obtained is described as "clear, cool and quite soft."

The water-horizon is the same as that at the dwelling on the Lorillard stock-farm, east of Jobstown,* at the depth of *356* feet, the elevation there being about 85 feet.

TWO ARTESIAN WELLS AT LAKEWOOD.

No 1.—For the Lakewood Water Company.

Elevation, 30 feet; diameter, 6 inches; depth, 600 feet.
Water rises 20 feet above the surface.
Overflows at the surface 150 gallons a minute.

No. 2.—For the Lakewood Hotel and Land Association.

Elevation, 30 feet; diameter, 6 inches; depth, 600 feet.
Water rises 20 feet above the surface.
Overflows at the surface 100 gallons a minute.

Kisner & Bennett inform us that in November they sank a well at Lakewood for the Lakewood Water Company, the location being "just below the dam and about 150 feet north of the tail-race and 300 feet north of the pumping station." They also state that "the ground is 25 feet lower than the Laurel House and 10 feet below the surface of the lake." The well flowed about 150 gallons a minute, and produced by pumping about 300 gallons a minute. The water rose 20 feet above the surface of the ground and 10 feet above the level of the lake.

---

* There is at the barn on this stock farm another well to a much deeper horizon, the depth of this water-horizon being at about 660 feet, although the boring was prospected to 715 feet.

Kisner & Bennett also inform us that in December they sank a second well at Lakewood, this time for the Lakewood Hotel and Land Association. This well "is located about 100 feet west of the N. J. S. R. R., under the hill, on the same level as the first well." The flow of this well is not as strong as that of the first well, being but "100 gallons a minute," and "the pumping capacity about 200 gallons."

The succession of strata, and the depths and thickness in each well are the same, and are, as described by Kisner & Bennett, as follows:

Sand and sandy clay,	80 feet	= 80 feet.
Marls,	332 "	= 412 "
Yellow sand bed,	30 "	= 442 "
Muddy sand.	55 "	= 497 "
Hard black clay,	40 "	= 537 "
Fine white sand with abundance of water,	53 "	= 590 "

Both the above wells were finished at the bottom with strainers 60 feet long.

FOUR ARTESIAN WELLS AT WEST ASBURY PARK.

Elevation, 20 feet; diameter of each, 6 inches.
Depth of Well No. 1—508 feet.
Depth of Well No 2—542 feet.
Depth of Well No. 3—558 feet.
Depth of Well No. 4—550 feet ±.

The American Pipe Co. has put down four artesian wells at West Asbury Park. The wells are arranged nearly in a straight line on ground about 20 feet above mean tide, and are about 200 feet apart. The drilling was done by Kisner & Bennett. Through the co-operative courtesy of the officers of the contracting company and of the well-drillers, we have been furnished with data respecting these wells and with one full series of the borings taken every ten feet in depth. The wells are said to yield, by pumping, about 150 gallons each per minute with a 23-inch vacuum.

After inspection of the specimens, both with and without the microscope, we present the subjoined record:

Soil, ...	0 feet to	6 feet.	Miocene.	
Brown clay with *sponge spicules*, . .	6 “ “	14 “		
Greensand marl, . . .	14 “ “	50 “	Upper marl bed.	Eocene.
Ash marl, ...	50 “ “	90 “		
Greensand marl, . . .	90 “ “	100 “		
Micaceous sand, . . .	100 “ “	150 “		
Greensand.	150 “ “	160 “		?
Ash mar., ...	160 “ “	170 “		
Sand, consisting of greensand grains and white quartz grains mixed, . . .	170 “ “	190 “		?
Ash-colored clay, . .	190 “ “	210 “		
Sand consisting of greensand grains and white quartz grains mixed, . . .	210 “ “	230 “		
Dark greensand, (glauconite), large *Nodosaria* and other *Foraminifera* throughout, ...	230 “ “	260 “		Cretaceous.
At 250 feet, *Echinus spines*.				
Greensand similar to next above but slightly darker, . .	260 “ “	310 “	Middle marl and lower marl beds.	
At 260 and 270 feet, *Echinus spines* and *Bryozoa*.				
Mixture of white quartz sand and greensand grains, .	310 “ “	360 “		
Echinus spines and comminuted *shell* at 330 feet; also fragments of flat forms of *echinus* at 340 feet.				
White quartz sand with a little greensand	360 “ “	400 “		
A little comminuted *shell* at 380 feet.				

Water-bearing at 380 to 400 feet.			Clay marls. Matawan formation	Cretaceous
Micaceous sand with a little greensand,	400 feet	to 420 feet.		
Nearly pure greensand, glauconite marl,	420 "	" 430 "		
Dark micaceous sand, with very little greensand,	430 "	" 450 "		
Darker micaceous sand with much greensand	450 "	" 470 "		
Same shade micaceous sand, with little greensand,	470 "	" 500 "		
Dark but lighter colored micaceous sand, with very little greensand—water-bearing,	500 "	" 558 "		

ARTESIAN WELL AT SEABRIGHT.

Elevation, 15 feet ; diameter, 6 inches to 344 feet, 4½ inches to 650 feet ; total depth 715 feet.
First water-horizon at depths of from 260 to 300 feet.
Second water-horizon at depths of from 350 to 390 feet.
Third water-horizon at depths of from 685 to 715 feet.
Water from the last horizon rises within 5 feet of the surface

This well was put down by Uriah White, and is much deeper than any well, so far as we know, heretofore sunk at this locality. It is on the Rumson road about one mile west of the draw-bridge. The record as furnished is as follows, no specimens having been obtained :

Succession of strata same as in former wells on Rumson Neck already noted in previous annual reports, to the depths of	190 feet to 230 feet.
Dark black mud, from	230 " to 675 "
Clay, 10 feet thick, from	675 " to 685 "
White sand, 30 feet thick, from	685 " to 715 "

A bluish stone was found at the depth of 375 feet, and sea-shells are said to have occurred more or less throughout the dark black mud.

Numerous wells, many of which have been noted in the annual reports for 1897 and 1898, have been put down in the vicinity of Seabright—reaching two higher water-horizons, the first at depths varying from 260 to 300 feet, and the second also varying from 350 to 390 feet. These are evidently in the upper portion of the clay marls and represent the 525 to 600-foot Asbury Park horizon. The supply of this well, however, is in the lower part of the clay marls, and is probably the equivalent of that at 1,083 feet at Asbury Park. It is also the same horizon as that which supplies wells at Atlantic Highlands, depth 465 feet; at Holmdel, depth 575 feet; at Brookdale, at the depth of 660 to 715 feet, and at Barren Island, N. Y., at the mouth of Jamaica Bay, L. I., at 720 feet.

Wells Reported by Matthews Bros.

The four following wells in Monmouth county, all of which draw from Cretaceous strata, are reported by Matthews Bros., who drilled them:

ARTESIAN WELL AT SEABRIGHT.

Elevation, 6 feet; diameter, 6 inches; depth, 275 feet.
Overflows 15 gallons a minute. Yields, when pumped, 69 gallons per minute.

Matthews Bros. have drilled an artesian well for the Seabright Hygeia Ice Company. The location is in the borough of Seabright, on Church street, about 100 feet from the South Shrewsbury river. The well is 6 inches in diameter, and has a natural flow of fifteen gallons per minute, and yields, when pumped, 69 gallons per minute. The elevation is 6 feet above tide-level.

The strata penetrated are:

White sand,	40 feet	= 40 feet.
Marl,	47 "	= 87 "
Cemented *shells*,	4 "	= 91 "
Gravel,	4 "	= 95 "
Dark-colored sand,	74 "	= 169 "
White clay,	14 "	= 183 "
Marl,	47 "	= 230 "
White sand and wood, water-bearing,	45 "	= 275 "

ARTESIAN WELL AT PORT MONMOUTH.

Elevation, 8 feet; diameter, 4½ inches; depth, 240 feet.

Matthews Bros. write: "We have sunk an artesian well fo the Port Monmouth Steamboat Co. The location is near th steamboat landing, the surface being 8 feet above tide-leve The well is 4½ inches in diameter and yields a supply of gallons per minute. The water is used to supply the boile and for other uses on the boats."

The strata drilled through were:

Made ground,	6 feet	=	6 fe
Salt meadow,	3 "	=	9 "
Yellow sand,	12 "	=	21 "
Marl,	29 "	=	50 "
Black sand,	47 "	=	97 "
White clay,	20 "	=	117 "
White sand and wood, water-bearing but salt,	43 "	=	160 "
Blue clay,	35 "	=	195 "
Gray sand, water bearing,	45 "	=	240 "

ARTESIAN WELL ON RUMSON BLUFF.

Elevation, 12 feet; diameter, 3 inches; depth, 282 feet.

Matthews Bros. write that they have put down an artesia well for Dr. Seman. The location is on the Rumson bluf about ⅛ of a mile west of South Shrewsbury river; the elevatio above tide-level is about 12 feet; the water rises to within 3 fee of the surface; the well is 3 inches in diameter.

The strata penetrated were:

Sand,	2 feet	=	2 feet
Clay,	3 "	=	5 "
Brown sand,	9 "	=	14 "
Black sand,	29 "	=	43 "
Marl,	42 "	=	85 "
Shells.	5 "	=	90 "
Pebbles (colored),	3 "	=	93 "
Dark sand,	70 "	=	163 "
White clay,	22 "	=	185 "
Marl,	39 "	=	224 "
White sand,	58 "	=	282 "

ARTESIAN WELL AT LITTLE SILVER.

Elevation, 18 feet; diameter, 4½ inches; depth, 280 feet.

Respecting this well, Matthews Bros. write as follows: "We have bored an artesian well for Dean & McMahon. Location about ¼ of a mile south of Little Silver depot. The elevation above tide-level is 18 feet, and the water rises to within 2 feet of the surface.

"The diameter of the well is 4½ inches, and is about 280 feet deep. We are not in possession of the different strata passed through in this well and so cannot send a better report."

[End of Matthews Bros.' records.]

ARTESIAN WELL SOUTH OF BABYLON, L. I., N. Y., ON MUNCIE'S ISLAND, GREAT SOUTH BAY.

Elevation, nearly at tide level; diameter, 3 inches to the depth of 200 feet,
and two inches below that; total depth, 270 feet. Continuation
of the Matawan-Cretaceous belt eastward beneath the
southern border of Long Island.

An artesian well was finished in the spring of 1898 for Dr. C. E. Muncie, at his sanitarium, on a meadow island in the Great South bay, inside of the Great South Beach, about three and one-half miles almost south of Babylon. From E. K. Hutchinson, of Oyster Bay, N. Y., who bored the well, we have received the following record:

Muck and sand, with shells, ...	0 feet to 10 feet.
Heavy yellow micaceous (?) sand and gravel, with water salt as the ocean and which stood nearly at the surface of the meadow. This stratum is very similar to that obtained from most of the shallow wells on Long Island, ...	10 " " 45 "
Clay and fine sand, like beach sand; sand and clay mixed. The color was blue and gray, ...	45 " " 150 "
Clay sand etc., much like the last only darker, with water which flowed 14 gallons a minute over the top of the casing, which was two feet above the ground. This water was fresh, but was colored black; pumped out much wood [lignite], about three wheelbarrow loads. The pipe seemed to be in wood, ...	150 " " 200 "

Lighter colored sand and clay mixed; amount of lignite gradually decreased. Sand a little heavier at the base, where good water was obtained. Water flowed from 2 inch pipe two feet above the surface 8 gallons a minute,	200 feet to 270 feet.

This well probably draws from sands within the clay marls or that division of the Cretaceous known in New Jersey as the Matawan formation, and which has been heretofore demonstrated by wells bored in the vicinity of Jamaica and on Barnum and Barren Islands, to pass northeastward across Raritan bay and to underlie a belt on the southern side of Long Island.

The well on Barren Island at the entrace of Jamaica bay was, however, bored much deeper (depth, 720 feet) and opened an horizon probably also stratigraphically much lower than that of this well south of Babylon. The latter probably draws from an horizon nearly equivalent to that of the wells of the Brooklyn water department in the vicinity of Jamaica, whose depths vary from about 150 feet to nearly 300 feet. The records of these wells are briefly tabulated on pages 162 and 163 of the Annual Report for 1896. In the same annual there is a very full stratigraphical record of the well on Barren Island.

ARTESIAN WELL AT WOODSIDE, L. I., N. Y.

Depth, 227 feet.

Stotthoff Bros. write that late in the year they commenced a boring for the Citizens Water Co., at Woodside, Long Island, N. Y., of which they furnish the record below:

Earth, clay and boulders,	38 feet	= 38 feet.
Hard clay mixed with sand,	60 "	= 98 "
Quicksand,	20 "	= 118 "
Blue clay,	20 "	= 138 "
Rock "gneiss layer, &c.,"	89 "	= 227 "

Of the above section, the beds below 98 feet, and perhaps below 38 feet to the rock at 138 feet, probably represent the eastward continuation of the New Jersey Raritan Cretaceous, which is now known to skirt the northern border of Long Island.

ARTESIAN WELL AT KENNEDYVILLE, MD.

Elevation, 20 feet; depth, 100 feet.

A few years since a well was drilled for the Baltimore and Delaware Bay Railroad at their station at Kennedyville, Md., which place is located slightly east of the 76th parallel of longitude, and about 4½ miles south of the Sassafras river. Thomas B. Harper, the contractor, reports the depth at about 100 feet, and the strata mainly clay till a gravel was reached at the bottom, in which he says there was plenty of water that came within ten feet of the surface.

ARTESIAN WELL AT CENTREVILLE, MARYLAND.

Elevation, 10 feet±; depth as finished, 428 feet. Boring was prospected beyond this to the depth of 665 feet

Water-horizons at 428 feet and 665 feet. Water rises nearly to the surface from both these horizons. The upper one only was, however, utilized.

Lucina crenulata Conrad, at	150 feet
Cylichna—sp? at	170 "
Terebratula harlani, Morton and Gryphea vesicularis, Lamarck, at	365 "
Exogyra costata, Say., and Pecten—sp? at	428 "

Early in the present year J. H. K. Shannahan contracted to sink a well at Centreville, Md., for the supply of the public water-works plant there. The work was done under the immediate supervision of Norman M. Shannahan, who has courteously furnished some data respecting the borings. A full series of specimens of earths from below the depth of 150 feet has been kindly furnished by the water company's engineer.

This well was finished with a depth of but 428 feet, but was, however, prospected beyond this to the depth of 665 feet, where another water-horizon was found, which, however, was not utilized.

After a careful study of the borings in the light of data furnished by N. M. Shannahan, supplemented by the lithological appearance of the various earths and the evidence presented by the fossils, we present the following record, with our geol interpretation upon the right:

	Thickness.	Total Depths.		
Made ground, ...	8 feet	= 8 feet,	Recent.	
Marsh mud, ...	17 "	= 25 "		
Green clay, not very hard, . . .	81 "	= 106 "		
Material described by the well driller as "a kind of gunpowder stuff." Specimens at 150 and 70 feet were a micaceous, sandy clay both containing Foraminifera. The mollusk, *Cardita ? granulata*, Say, occurred at 50 feet, also a *Cylichna*——sp. at 170 feet,	64 "	= 170 "	Miocene.	
Olive-yellow, coarse sand, consisting of a mixture of greensand and white quartz grains, somewhat finer at the base, .	60 "	= 230 "	Eocene, = 186 feet.	
Nearly pure greensand (Glauconite). A few white quartz sand grains, ...	10 "	= 240 "		
Olive-colored sand, same shade, composition and texture as at 170 to 230 feet, . . .	40 "	= 280 "		
Very decidedly darker olive-colored mixture of greensand and yellow quartz sand grains, ...	76 "	= 356 "		
Gray sand, ...	4 "	= 360 "	Rancocas.	Cretaceous.
Stony lime sand (concretions), consisting of greensand and yellow quartz sand cemented with a whitish material, .	5 "	= 365 "		
Terebratula harlani, Morton and *Gryphea vesicularis* Lamark, in a stratum, say, ...	5 "	= 370 "		
Mixture of greensand and yellow quartz sand, contains *Nodosaria* and other *Foraminifera*, varying from fine to coarse sands and from quite light to medium dark olive color. At 428½ there was brought up an *Exogyra* and a *Pecten*, ...	60 "	= 430 "		

Reddish mixture of greensand and reddish-yellow quartz sand.	30 feet	= 460 feet.	Matawan.	Cretaceous.
Very dark olive-colored mixture of clay, greensand and olive-colored quartz sand,	20 "	= 480 "		
Light olive-yellow mixture of greensand and yellow quartz sand,	10 "	= 490 "		
"Light clay, 490 to 530 feet,"	40 "	= 530 "		
"Greenish clay, 530 to 650 feet,"	120 "	= 650 "		
Light sand with water that stood 3 feet below the surface,	5 "	= 655 "		

A well has recently been put down at Chesapeake Beach on the opposite side of the Chesapeake bay, through beds which we correlate with those penetrated by this well. For such correlation and for remarks upon the dip of the beds, read the succeeding record.

ARTESIAN WELL AT CHESAPEAKE BEACH, MARYLAND.

Elevation, 10 feet+; depth, 295 feet

A well has been recently put down at Chesapeake Beach, a new pleasure resort on the western shore of Chesapeake bay, nearly four miles south of Herring bay. The locality is the terminus of the recently constructed Chesapeake Beach Railroad, whose line runs nearly southeastward from Washington, D. C.

From Dr. W. B. Clark, who informed us of this well, we learn that it has a depth of 295 feet, the first 60 feet being in Miocene, the remaining 235 feet being mainly Eocene.

The writer's study of wells in this region in which he has been aided by some vertical sections prepared by him from various data in hand, inclines him to the view that the following is probably the correct correlation of the strata in this well and in the one of the preceding record at Centreville, this well being say eight or ten miles further up the slope of the beds. Total depths from the surface are given :

	Chesapeake Beach.	Centreville.
Miocene from near the surface to, ...	60 feet.	170 feet.
Eocene to, ...	250 "	356 "
The Rancocas division of the Cretaceous here intervenes.		
Water bearing horizon, at	295 "	428 "

The writer's section indicates the dip of the Miocene beds to be 10 to 12 feet per mile, towards the ocean, and the dip of the Cretaceous bed to be about 25 feet per mile in the same direction.

ARTESIAN WELLS ON TILGHMAN'S ISLAND, MD.

Depths, 370 to 420 feet.
Water rises 12 feet above tide.

I. A. Harrison, of Tilghman, Md., reports having sunk a number of wells on Tilghman's Island, on the eastern side of Chesapeake bay and north of the mouth of the Choptank river. He says "the depths of these wells vary from 370 to 420 feet, according to the location" of each, and that "the dip is about 30 feet per mile to the southeast." He also says the strata in all the wells are very much alike, and describes the general section as follows:

Clay or sand of a greenish color, ...	to 150 feet.
Three or four thin "pans" of rock imbedded in black sand.	
Continuation of black sand and clay, ...	to 370 and 420 feet.
"The water-bearing sand at the base is a thick black sand, very coarse, interspersed with a shelly formation, the whole seeming like soft sandstone."	

In all the wells this basal sand produces an abundance of water, which has been noticed to rise 12 feet above tide-level at the south end of the island.

ARTESIAN WELLS ON TAYLOR'S ISLAND, MD.

No 1.—Elevation, 5 feet? depth, 155 feet.
No. 2.—Elevation, 5 feet? depth. 390 feet.
Water from No. 2 rises within 2 feet of the surface.

Hon. Levi D. Travers some years since furnished us with data respecting two wells on Taylor's Island, Maryland, on the eastern side of Chesapeake bay.

No. 1, the more shallow well (depth 155 feet), he says is on his brother's place, near the river, while No. 2 (depth 390 feet) is on his own property, one mile from the former, and in the middle of the island, the whole of which is elevated only a few feet above tide.

Of his own well he makes the following statement: "Within the first thirty feet water was abundant but brackish, and between 20 and 30 feet was strongly impregnated with iron. Scarcely any water was found between 30 and 250 feet, and only four gallons a minute at that depth. Between 250 and 390 there was no increase of the flow of water."

He also furnishes the following stratigraphical data for this well:

Quicksand,	8	feet	to	30	feet.
No record.	30	"	"	40	"
Whitish sand,	40	"	"	50	"
Gravel, marl, clay and sand mixed,	50	"	"	100	"
Some gravel, clay and greenish sand,	100	"	"	150	"
White sand. *Water-horizon* of well No. 1,	150	"	"	155	"
Gravel. clay and sand similar to that at 100 to 150 feet,	155	"	"	200	"
Clay and sand, without marl, principally black and brown sands,	200	"	"	245	"
White sand with *water*,	245	"	"	270	"
Clay and sand without marl, principally black and brown sand,	270	"	"	390	"

At the depth last named, on "what is called black sand," further boring of No. 2 was abandoned. The water-supply probably comes from the white sand at 245 to 270 feet.

Leach Brothers, who drilled this well, describe the beds between 50 and 150 feet as mainly "blue clay," and the material entered at 270 feet as "hard clay."

ARTESIAN WELL ON THE SEVERN RIVER, GLOUCESTER COUNTY, VA.

Elevation, 5 feet ; diameter, 6 inches ; depth, 716 feet.
Overflows at one foot above the surface, 50 gallons a minute.
Overflows at 23 feet above the surface, 7 gallons a minute.
Terebratula harlani, Morton, at about 570 feet.

In 1898 a six-inch well was put down in Gloucester county, Va., on the Severn river, an estuary of Mobjack bay, which is itself an indentation on the western shore of the Chesapeake, north of the mouth of the York river. The well was bored for Alfred W. Withers, of Roanes, Va., who has furnished the data tabulated above, and who further states that *shells* were found at different depths, and that deep strata of blue clay and fine packed sand were penetrated, and also that water was found at various other depths than that above noted, which in some cases would rise within a few feet of the surface and afford a considerable quantity for pumping purposes, while at other depths it would flow small, thin streams, not enough to be of any practical use.

From A. W. Withers, and also from A. P. Sharp, a chemist to whom a sample of the water from the stratum at the base of this well was sent, we learn that the water is quite strongly charged with mineral matter, consisting in part at least of "chlorides of soda, potash, lime and magnesia."

N. H. Darton, of the U. S. Geological Survey, has also submitted to the writer specimens of fossil mollusks believed by him, from information he has received, to have come from the depth of 560 to 573 feet. Among these mollusks are numerous shells of a brachiopod, *Terebratula harlani*, Morton.

There are also two other bivalves represented, neither of which we are able certainly to identify. One of these is a cast that somewhat resembles a *Calista*, but that this is the correct genus we cannot be positive. The other is represented by a number of shell fragments of a *Pecten*, the specific form of which we are as yet unable to determine.

Respecting the occurrence of *Terebratula harlani*, Morton, southward from New Jersey, the writer would state that he has so far had this fossil placed in his hand from well-borings at

Centreville, Md., depth 365 feet; from Fairport, Va., depth 640 feet; from this locality, depth 560 to 573 feet; and from a well at the Hotel Chamberlin, at Old Point Comfort, Va., depth said to be 840 feet, though it is possible that at the latter place its true position was somewhat higher.

At all the localities, except Fairport,* this *Terebratula* was associated, in the specimens received, with a conglomerate of greensand grains and quartz sand grains cemented together; the color, however, of the conglomerate varied at the several localities. We are inclined to consider that this conglomerate represents the limesand layer that occurs above the *Terebratula* horizon of the Middle Marl bed in New Jersey.

ARTESIAN WELL, NEAR NORFOLK, VA., AT LAMBERT'S POINT.

Elevation, 10 feet; { Diameter, 8 inches to 400 feet; Diameter, 7 inches to 616 feet; } Depth 616 feet.

Water flows 65 gallons a minute from the top of the casing, seven feet above the surface.

Upper two-thirds mainly through the Miocene.

Lower one-third through the Ripley or Matawan Cretaceous.

Ripley—Matawan fossils.

Dip of Miocene beds about 14 feet per mile.

Dip of Cretaceous beds about 30 feet per mile.

About the year 1890 an artesian well was sunk for the use of the Norfolk and Western R. R. Co. at Lambert's Point, some two miles northwest of Norfolk, Va. The well draws its supply from a fine sand, "apparently silica and mica," between the depths of 610 and 616 feet. The quality of the water is not, however, entirely satisfactory, being somewhat saline. It is, however, used by the workmen in preference to other water obtainable at the locality. We are informed that "sixty-five (65) gallons a minute is discharged (by overflow) seven feet above the ground," and that the "temperature of the water is 70 degrees Fahrenheit."

From Charles S. Churchill, the company's engineer for maintenance of way, the writer, early in 1891, received small portions of the borings from various depths, representing, however, nearly a full series. This series is a duplicate of a somewhat larger one retained at that time in the office of the company.

---

* The conglomerate may or may not exist at Fairport, but if so, no specimens of the rock were sent us.

Either this retained series or another duplicate one has since then been placed in the hands of N. H. Darton, of the U. S. Geological Survey, who has noted the occurrence in the lower strata near the base of the well of Ripley Cretaceous fossils.* These we will again refer to in this record, corroborating his observations as to their age by additional ones of our own.

Below we separately present for each stratum a triple record. The first is that made by N. H. Darton,† from an examination of the borings submitted to him. We have added thereto his initials, N. H. D.

The second is that of George S. Churchill, the company's engineer. We also add thereto his initials, G. S. C.‡

The third consists of notes and comments by the present writer, and are the results of a study of the borings in his possession. Mention is made therein of fossils, both microscopic and macroscopic.

A bed of clay sparingly diatomaceous occurs at a depth of 17 to 44 feet, containing mixed marine and fresh-water forms of both Pleistocene and Miocene species. This bed we correlate in age with a similar bed that occurs at Moore's Bridges between the depths of 21 and 65 feet. (See last paragraph, page 98.)

The specimens from the central or lower portion of the borings fail to reveal the occurrence of the great Miocene diatom bed that exists in the deep wells at Norfolk and Old Point Comfort.

It is interesting to note in the basal beds penetrated by this well certain Ripley or Matawan Cretaceous marine fossils, as noted in the succeeding record.

The writer has made a very careful comparison, stratum for stratum, of this well and of one at Moore's Bridges, six and one-half miles east, to the depth in the latter of 815 feet, and finds that the beds of the upper two-thirds or thereabouts on both wells are Miocene and Eocene,§ excepting the first 50 or perhaps 65 feet, which in both cases probably represents quite recent Pleistocene. The lower one-third or less in both wells is of Ripley or Matawan Cretaceous age. The dip of the Miocene beds near their base he finds to be about 14 feet to the mile, and of the Cretaceous beds beneath to be about 30 feet per mile, the dip being eastward. In the succeeding record of the Norfolk waterworks deep well (1,760 feet), at Moore's Bridges, we note more particularly the correlation of the strata and of their contained fossils.

---

* Bulletin Geol. Soc. of America, 1898, Vol. IX, page 414 to 416.

† Bulletin No. 138 U. S. Geol. Survey, 1896, page 172.

‡ This we copy verbatim from a record furnished by G. S. Churchill to the present writer in 1891.

§ The Eocene, however, compared with the Miocene, is relatively quite thin in these two well-sections.

The clays in the well-borings at the base of the Miocene and occupying the interval between the depth of 475 and 625 feet (including the great Miocene diatom bed at 580 to 625 feet) seem not to occur at all in this well, thus evidencing considerable unconformity between the Cretaceous and the overlying post-Cretaceous beds.

The water-bearing horizon is probably the equivalent of that the depth of 805 to 810 feet at Moore's Bridges (see page 92), and at the depth of 562 feet at Money Point,* on the southern branch of the Elizabeth river, five miles south of Norfolk.

The writer deems it very probable that the same Cretaceous beds that occur at the base of this well were entered by a boring made many years since at Newport News† to the depth of about 600 feet.

"Beach sand, shell fragments" (N. H. D.). "Clean sand" (G. S. C.). Sand slightly yellowish, shell fragments, *Turritella* —— Sp. ? &c.	Surface to 17 feet.
"Bluish clay, shell fragments" (N. H. D.). "Stiff blue mud" (G. S. C.). ***Diatoms, sponge spicules*** and broken ***shell.***	17 feet to 44 feet.
"Gray micaceous sand fine; *shell* fragments" (N. H. D.). "Fine gray sand" (G. S. C). Contains *foraminifera* and *echinus spines*	44 " " 183 "
"Greenish gray sandy clay" (N. H. D.). "Sand mixed with blue mud" (G. S. C.). Contains *sponge spicules* some of them pin-head forms.	183 " " 191 "
"Gray micaceous sands" (N. H. D.). "Fine sand mixed with some mud" (G. S. C.). No organisms observed in this.	191 " " 233 "

---

* Artesian Wells, &c., N. H. D. Darton.
Bulletin 138, U. S. Geol. Survey, pages 166, 173, 183 and 188.

† Same Bulletin, pages 166 and 173.

"Fine sand and clay, greenish gray, tough when dry, shell fragments, *Pecten*, *Venus*" (N. H. D.). "Cemented mixed mud sand and *shells*" (G. S. C). Clay with comminuted *shell* exactly identical in all respects with clay and small broken shell from Norfolk water-works well at the depth of 325 feet.	233 feet to 264 feet.
"Gray clay" (N. H. D.). "Stiff blue mud" (G. S. C.). Contains *sponge spicules*.	264 " " 286 "
"Fine gray sand, shell fragments" (N. H. D). "Mixed fine gray sand and blue mud" (G. S. C.). Contains greensand grains or glauconite.	286 " " 355 "
"Gray clay" (N. H. D) "Cemented blue mud" (C. S. C.).	355 " " 377 "
"Fine gray sand, shell fragments" (N. H. D.) "Fine sand and mud" (G. S. C.). Contains *echinus spines*, *sponge spicules* and fragments of *mollusks*.	377 " " 397 "
"Dark gray clay" (N. H. D.). "Cemented blue mud" (G. S. C). No specimen received by the writer.	397 " " 407 "
"Gray sand, moderately coarse; some glauconite ' (N. H. D). "Fine dark-gray sand, consisting of a large amount of white particles mixed with black particles" (G. S. C.). The "white particles" are the shells of *foraminifera*. the "black particles" are glauconitic greensand. This stratum also contains *echinus spines*.	407 " " 526 "
"Small gravel, *shell* fragments" (N. H. D.). "Very coarse, clean sand mixed with pieces of *shells*" (G. S. C.).	526 " " 534 "
"Rock (no sample)" (N. H. D.). "Half formed stone made of blue mud, sand and shells" (G. S. C.). Rock, two specimens furnished the writer, one of them a fine stone without fossils, the other consists largely of very small fragments of mollusks unidentifiable.	534 " " 540 "
"Gray clay" (N. H. D.). "Cemented blue mud" (G. S. C.). Clay contains *foraminifera*.	540 " " 563 "

"Rock stratum ; *shell* fragments" (N. H. D.). "Same material as 534 feet to 540 feet" (G. S. C.). Rock stratum. Specimens received contain casts of what C. W. Johnson refers to a young *Axinea* —— Sp.? and also one individual form which he identifies as probably *Gouldia decemnaria* Conrad. There was also a single quite perfect flat valve of *Gryphea vesicularis*, Lamarck. This was received separate, however, from the rock matrix N. H. Darton reports *Exogyra* from the depth of 563 feet.*	563 feet to 564 feet.
"Gray clay" (N. H. D.) "Half formed stone made of compressed blue mud ; stone cuts like chalk" (G. S. C.). Dark, hard, fine micaceous sandy clay, well laminated ; *does* "cut like chalk."	564 " " 568 "
"Rocky strata, with thin layers of clay and shell fragments" (N. H. D.). "Same material as between 534 and 540 feet interspersed with thin layers of clay" (G. S. C.). No specimen furnished the writer. This is probably the stratum from which T. W. Stanton determined the following Marine Ripley Cretaceous fossils as noted by N. H. Darton :* "Astarte octolirata, Gabb. Ostrea plumosa, Morton. Gryphea vesicularis. Liopistha (Cymella) bella, Conrad Corbula Sp. Modiola, Sp. Baculite ?".	568 " " 603 "
"Small gravel in coarse sand ; *shell* fragments, water" (N. H. D.). "Medium coarse sand with broken *shells*" (G. S. C). The writer's specimen agrees with both the above descriptions. The *shell* fragments are not identifiable.	603 " " 606 "
"Rocky stratum" (N H. D.). Same as between 534 and 540 feet (G S C). The writer's specimens show comminuted shell. one individual form being an *Exogyra*, a genus also noted at this depth by N. H. Darton.*	606 " " 610 "

---

* **Bulletin Geol. Soc. of America, 1896, Vol. IX, page 415.**

"Gray sand; moderately coarse; micaceous; *oyster shell*" (N. H. D.). "*Water-bearing* stratum of fine sand (silica and mica apparently)" (G. S. C.). Fine siliceous gray sand with considerable mica, closely similar to a specimen the writer has from the depth of 805 feet, at Moore's Bridges Norfolk water-works, six and one-half miles eastward and which was there also water-bearing.	610 feet to 616 feet.

ARTESIAN WELL NEAR NORFOLK, VA., AT MOORE'S BRIDGES. BORED FOR THE NORFOLK CITY WATER DEPARTMENT.

Elevation, 10 feet; depth, 1,760 feet.
Diameter, 12 inches to 780 feet
Diameter, 10 inches to 1,210 feet.
Diameter, 8 inches to 1,539 feet.
Diameter, 6 inches to 1,708 feet.
Diameter, 4½ inches to 1,760 feet.

Water flowed over the surface at the following depths: *

At 738 feet 10 gallons a minute; salt, 112 grains per gallon.
The interval between 738 to 775 feet is described as containing water its entire depth.
At 785 feet 35 gallons a minute. Salt, 125 grains per gallon.
At 805 feet to 810 feet 25 gallons a minute. Saline.
At 950 feet 75 gallons per minute. Slightly salt.
At 975 feet to 980 feet 10 gallons per minute. Slightly salt.
At 985 feet 15 gallons per minute. Slightly salt.
At 1,038 feet 25 gallons per minute. Salt, 159 grains per gallon.
At 1,072 feet 150 gallons per minute. Salt, 164 grains per gallon.
At 1,190 feet 350,000 gallons per 24 hours. Fresh at first but afterwards became salty.
At 1,255 feet to 1,290 feet, some water.
At 1,480 feet good flow of very salt water.
At 1,510 feet to 1,517 feet salt water overflowed
At 1,535 feet salt water overflowed.
At 1,742 to 1,760 feet, or immediately below, there was evidently a water-yielding horizon, as indicated by the sand rising up in, and choking the casing, doubtless caused by strong pressure of water rising and carrying the sand with it.

---

* In a well drilled some years previously, on the same premises, to the depth of 730 feet, water was obtained that flows over the surface. This must be the same horizon now noted at 738 feet. The water from the former well, we have been informed, "has 262 parts per 100,000 of mineral matter—192 common salts, 52 soda, 7 lime and some magnesia, also .3 of a part of free ammonia."

Beds of diatoms and sponge spicules occur at the following depths:

Bed No. 1,	Diatoms at	25 feet to 65 feet.	Late Pleistocene.
Bed No. 2,	Sponge spicules at . . .	355 " " 580 "	Miocene.
	Diatoms at	580 " " 625 "	
Bed No. 3,	Diatoms at	665 " " 685 "	

Dip of Miocene strata about 14 feet per mile.
Dip of Cretaceous strata about 30 feet per mile

During the years 1896-97-98 a deep artesian boring was made at Norfolk, Va., for the water department of that city. The well is located at Moore's Bridges, five miles eastward from the city. Through the courtesy of the contractor, C. L. Parker, of Ithaca, N. Y., and of George W. Wright, chief engineer of the water department, both of whom have an appreciation of geological science, we have been furnished with specimens of the borings, taken every ten feet from the depth of 25 feet downward, and also with records of strata and other information. The boring was made by the use of the drill and sand bucket, a process which furnishes unusually good specimens for geological study, much better, in fact, than the various hydraulic or jetting methods that are often employed in drilling through soft beds such as were penetrated by this well. The diameter of the boring at the commencement was 12 inches; this was successively reduced to 10, 8, 6 and 4½ inches at the depths noted in the above outline.

The various depths to water, its quality and the amount of flow in each instance, are as tabulated at the head of this record. The strong flow of 75 gallons per minute at 950 feet, doubtless represents the horizon, the top of which was met with at the depth of 920 feet at "The Chamberlin," at Old Point Comfort,* eleven miles nearly due north of the locality of this well.

From a careful study of the samples of earths and of the contained fossils, both macroscopic (*shells*) and microscopic (*sponge spicules*, *diatoms* and *foraminifera* and *coccoliths*), supplemented by information contained in various letters from G. W. Wright and C. L. Parker, the author is enabled to present the subjoined detailed record:

---

*Consult record of the well at Old Point Comfort, Ann. Rept. Geol. Survey, N. J., 1898, pages 122 to 126.

Usual surface sand, to	18	feet.			
Sand, water-bearing,	18	"	to	21	feet.
Bluish clay, with *fossil diatoms* and numerous *sponge spicules* of recent geological age ; also one specimen of a small *Mactra*,	21	"	"	65	"
Bluish clay, without diatoms,	65	"	"	85	"
Small streak of gravel, at 80 feet.					
Clayey sand and gravel,	85	"	"	105	"
Pecten Madisonius Say, at 105 feet.					
Clayey sand with some rather large white quartz pebbles small *echinus spines*,	105	"	"	115	"
Clayey sand,	115	"	"	125	"
*Rangia** *cuneata* Gray (= *Rangia clathrodonta* Conrad) at 125 feet.					
Clayey sand, with comminuted shell but no micro-organisms,	125	"	"	165	"
Fine bluish clay, no micro-organisms, *Pecten Clintonius* Morton, at 185 feet,	165	"	"	250	"
Clay, with much sand, described as consisting of "10 feet of shells, each shell being about five inches in length, the boring for 10 to 20 feet would not stand up to drill through. The shells fell in and had to be cased off."	250	"	"	260	"
Sandy clay, decidedly darker than at 165 to 250 feet and of a somewhat greenish cast, no micro-organisms,	260	"	"	285	"
Twenty feet of soft clay, which "ran up into the well for 20 feet or so till cased off by the pipe,"	285	"	"	305	"
Clay,	305	"	"	310	"
Ten feet of very sandy clay that "would cave in and had to be cased off, as at 285 to 305 feet,"	310	"	"	320	"
Sandy clay, no micro-organisms,	320	"	"	355	"
Note—No micro-organisms in any of the above beds from 260 to 355 feet.					
Sandy clay, with a few *sponge spicules*,	355	"	"	375	"
Fine clay, less sandy, *sponge spicules*, plentiful throughout,	375	"	"	445	"
Fine clay, *sponge spicules*, but less plentiful Some comminuted *shell* at 465 to 475 feet.	445	"	"	485	"
Fine clay, with only a few *sponge spicules*,	485	"	"	505	"
Fine clay, no micro-organisms,	505	"	"	555	"
Fine clay, with small microscopic black objects, either discs or globules, nature not understood.	555	"	"	580	"

---

* The genus Rangia was formerly known as Gnathodon, a name that is now relegated to the synonymy, because pre-occupied in another group of the animal kingdom.

Fine clay, slightly lighter in color, described by the well driller as "brown mud," contains *marine diatoms* throughout: also *sponge spicules* and *foraminifera*,	580 feet to 605 feet.
Fine clay, similar to next above, also contains *diatoms*, *sponge spicules* and *foraminifera*, but with the addition of *coccoliths*;	605 " " 625 "
Greensand marl (glauconite) mixed with white quartz sand and an abundance of the white shells of *Textularia* and other *foraminifera*,	625 " " 635 "
Dark greenish clay with *foraminifera*,	635 " " 665 "
Sticky, hard clay, with *coccoliths* and *foraminifera*, also a few *diatoms*,	665 " " 685 "
Similar clay, with *foraminifera* and greensand or glauconite grains but no diatoms, described by the driller as "sand gravel and marl,"	685 " " 705 "
"Sticky bed" of lighter colored fine clay, with *foraminifera*,	705 " " 728 "
Specimen from 715 feet showed much comminuted shell, some of the fragments consisting apparently of fine laminæ with an irridescent nacreous lustre.	
Sand seam, a small flow of *water, with 112 grains of salt per gallon*	728 " " 730 "
Soft clay more sandy, with much comminuted *shell*,	730 " " 735 "
Seam of small gravel,	735 " " 745 "
Water flowed at 738 feet, salty.	
Very sandy greenish clay,	745 " " 765 "
Water at 740 to 750 feet,	
Comminuted shell at 755 to 765 feet; also one lower valve of an *Exogyra*.	
Gray sand, with a little glauconite, flow of water at 780 to 783 feet,	765 " " 783 "
All the sands between 750 and 783 feet are said to "have run into the well." This indicates an *abundance of water between these depths*.	
Both upper and lower valves of several individuals of the two following mollusks were received labeled "from above 780 feet," to wit numbers of specimens of a small young *Exogyra*, surface of the lower or convex valve mostly smooth; a few, however, showed faint costæ, as in E. costata, Say; the upper or flat valves are rugose.	
And small or young forms of *Gryphea vesicularis* Lamarck.	

"White sticky clay." No specimen,	783	feet to	785	feet.
Gray quartzose sand without any greensand, at times clayey, contains *water at 786 to 805 feet*, which flowed over the surface 35 gallons a minute; *slightly salt, 125 grains per gallon*,	785	" "	815	"
Decidedly darker gray sand, also without greensand,	815	" "	835	"
Lighter colored sand,	835	" "	870	"
Gray very sandy clay,	870	" "	890	"
"Black sticky mud," so described, but of this no specimen was received,	890	" "	898	"
Clayey sands or alternations of sands and clays,	898	" "	991	"
Lignite at 925 and 965 feet.				
Water flowed over the surface at 950 feet 75 gallons per minute, *slightly salt.*				
Water also flowed over the surface at 975 to 980 feet 10 gallons per minute *slightly* salt, and at 985 feet 15 gallons a minute, also *slightly salt.*				
Slightly yellowish sandy clay,	991	" "	1,033	"
Gray sands, water-bearing,	1,033	" "	1,078	"
Water flowed over the surface at 1,038 feet 25 gallons a minute, *salty.* Pebbles at 1,060 and 1,070 feet. *Water* again flowed over the surface at 1,072 feet, 150 gallons a minute; *salt, 160 grains* per gallon.				
Gray sands and clayey sands,	1,078	" "	1,120	"
Darker sandy clays, texture fine to coarse, contain no micro-organisms,	1,120	" "	1,160	"
Heavy pebbles at 1,130 feet.				
Coarse gray sand,	1,160	" "	1,190	"
Lignite at 1,160 feet.				
Heavy pebbles at 1,190 feet from which *water* rose to the surface but, it is said, did not overflow. Quantity, 350,000 gallons per 24 hours fresh at first, afterwards became *salty.*				
Reddish and reddish-yellow clays and clayey sands. Heavy pebbles at 1,210 feet,	1,190	" "	1,230	"
Dark fine clay, described by the driller as "black marl," but it is not a greensand marl,	1,230	" "	1,255	"
Sand, slightly yellowish-olive in color, yielded "some water,"	1,255	" "	1,290	"
"White marl," (?) so described. No specimen received,	1,290	" "	1,295	"

Reddish and yellowish clays and sandy clays described as "red marl," though not a glauconite marl.	1,295 feet to 1 330 feet.
G. W. Wright states that at 1 320 feet he obtained "a fossil shell with a peculiar curl to it [an *Exogyra*], and had sent it to Prof. Darton, who, he further states, "was surprised at its occurrence at this point," a surprise in which the present writer also shares.	
Alternations of sands and clayey sands varying from whitish to yellowish in color	1 330 " " 1,580 "
Heavy pebbles at 1,470 to 1,480 at 1,540 and 1,570 feet.	
The following clay seams, of which no specimens were received, were described by the well-driller for this interval, viz.: Clay seam, 1 356 to 1,358 feet. "Blue marl," (?) 1,400 to 1,410 feet. "Black marl," (?) 1,557 to 1,560 " "Blue marl, (?) 1,568 to 1,571 "	
The water-bearing horizons were as follows: "Good flow, *very salt water*, at 1,480 feet." Flow of *salt water* at 1,510 to 1,517 feet, and also at 1,535 feet.	
Dark clay, slightly variegated,	1,580 " " 1,600 "
Yellowish or slightly reddish-yellow coarse sands and clayey sands,	1,600 " " 1,680 "
The following, of which no specimens were received, except one at 1,680 feet, were described by the well driller: Blue (marl ?), 1,640 to 1,647 feet. Blue (marl ?), 1,650 to 1,654 " Blue (marl ?), 1,677 to 1,680 "	
The specimen at 1,680 feet shows these seams to be a fine non-glauconitic clay, which was doubtless blue in shade when wet, as it came out of the well.	
Dark, coarse, very sandy clay, slightly variegated with red, similar in most respects to that at 1,580 to 1,600 feet, but coarser and more sandy,	1,680 " " 1,700 "
The following thin seams, of which no specimens were received, are described by the driller: Blue (marl ?), 1,683 to 1,685 feet. Marl (?) and clay, 1,693 to 1,695 feet.	

Reddish variegated clay, ...	1,700 feet to 1,742 feet.
' Sand, which ran up some 150 feet or more into the well with great pressure," *evidently strongly water-bearing*	1,742 " " 1,760 "

No specimen was received of this.

Having reached the depth just noted, 1,760 feet, the further drilling was discontinued and the pipes cut at certain of the water-horizons, which, in passing downward, had been cased off. This permitted the water to enter the well so that it now, we are informed, "produces by natural flow, some 60,000 gallons of water each day, which is used with the city water-supply." Respecting the quality of the water from various depths, C. L. Parker recently writes, "large and small veins of water were found, some flowing and some non-flowing, nearly all of which were more or less saline in character, but otherwise of good quality." After noting that "a flowing water at 730 feet had 112 grains of salt per gallon, one at 1,038 feet had 159 grains and another at 1,072 feet had 164 grains, as per analysis made at Richmond." He states that "a gradual reduction in the amount of salt shows as time passes."

It may be proper to state respecting the occurrence of Exogyra that Dr. N. H. Darton, in a communication before the Geological Society of America,[*] at the Montreal meeting, 1889, says: "The fossils from the depth of 715 to 775 feet were all of one species, which is a small *Exogyra* precisely similar to *E. Costata*,[†] but having a smooth surface and showing only very faint costations. They vary in length from ¼ inch to 1¼ inches. The shell from 1,320 feet clearly is of the same species, and, although it is claimed by the drillers there can be no mistake about the depth stated, I do not feel convinced as to its authority. However, it cannot be ignored."

Three beds containing *diatoms* and more or less *sponge spicules* have been revealed by microscopic examination; two of these also contain *foraminifera*, and one, the lowest, contains *coccoliths* in addition.

The first of these beds occurs at the depth of 21 to 65 feet, and contains an assemblage of marine diatoms mixed with a few fresh-water species. It also contains a mixture of recent diatoms, such as are now living on the Atlantic coast, and also of Miocene forms which have probably been contributed by the erosion and re-deposition in geologically recent times of Miocene clays. These peculiarities have also been noticed by the writer as pertaining to a deposit shortly below the surface of the Dismal Swamp.* The bed is probably continuous between the two localities. The presence of *Triceratium favus*, Ehr., a diatom which does not occur in the Miocene, indicates a recent age for this bed. It is probably late Pleistocene.

---

[*] Bulletin Geological Society of America, Vol. IX, pages 414 to 416, Discovery of Marine Cretaceous in a boring at Norfolk, Va. N. H. Darton.

[†] As recorded above, our specimens from doubtless the same horizon showed, associated with the Exogyra, also Gryphea vesicularis.

The second infusorial bed occupies the interval between the depths of 355 and 625 feet, and presents three phases or subdivisions, as follows:

At 355 to 580 feet, sponge spicules only.
At 580 to 605 feet, diatoms, sponge spicules and foraminifera.
At 605 to 625 feet, diatoms, sponge spicules, foraminifera and coccoliths.

The assemblage of diatoms includes the characteristic forms especially indicative of the great 300 to 400-foot Miocene diatom bed of the Atlantic coastal plain.

The third diatom bed is sparingly diatomaceous. It occurs between the depths of 665 and 685 feet and probably marks the division line between the Miocene and the underlying Eocene formation.

After a final careful comparison of the specimens of the borings with the above record, which, as already stated, has been made from a separate study of each specimen and comparison of the same with several descriptions received from those who personally supervised the drilling, the writer considers the various beds penetrated by this well as the equivalent of and extension southward of the following geological subdivisions known and heretofore described by Prof. G. H. Cook and others as underlying southern New Jersey. The intervals of depth occupied by each of these divisions is noted on the right.

---

* Proceedings of the Academy Natural Sciences, Philadelphia, 1898, pages 422 to 427. Fossil Mollusks and Diatoms from the Dismal Swamp, Va. and N. C., &c. Lewis Woolman with Notes on the Diatoms. C. S. Boyer.

		Intervals of depth.
Pleistocene, Recent,		0 feet to 65 feet.
Miocene,		65 " " 625 "
	Miocene mollusks clearly defined at 105, 125, 185 feet, and *probably* at 250 feet, &c.	
	Sponge spicules at 355 to 585 feet.	
	Characteristic Miocene marine diatoms at 585 to 625 feet.	
	(See details in record above.)	
Eocene,		625 feet to 715 feet.
Cretaceous,	Rancocas,	
	Matawan, with *Exogyra* and *Gryphea*.	715 " " 783 "
	Matawan (?) or Raritan (?),	783 " " 1,320 "
	Exogyra at 1,320 (?)	
	—Raritan (&c. ?),	1,320 " " 1,740 "

Two other wells have been put down in recent years in this region, one on either side of the James river, from each of which the writer has an ample series of specimens of the borings which have been used for comparison with those from this well. One of these wells is at Lambert's Point, a short distance north of Norfolk, (see record, page 87,) and the other at the Hotel Chamberlin, Old Point Comfort, adjacent to Fortress Monroe.*

On comparing the borings from Old Point Comfort and those to the depth of 950 feet in this well at Moore's Bridges, Norfolk, there is found to be considerable correspondence in the succession of strata, with, however, but little variation in depth to corresponding changes in material, say not over from 25 to 50 feet, the depths being the greater at Norfolk. The Old Point Comfort well is eleven miles slightly west of north from the Moore's Bridges well, while the strike of the beds is probably nearly north and south. In this connection we may note that the great Miocene diatomaceous bed of the Atlantic coastal plain occurs at the following depths in these wells, viz., in the Old Point Comfort well at 530 to 560 feet, in the Norfolk Moore's Bridges well at 580 to 625 feet.

On comparing the borings from this, the Moore's Bridges, and the Lambert's Point wells, there is also seen to be a close correspondence, lithologically, in the succession of the materials penetrate, but a decided difference in the depths to corresponding changes, the depths being much greater at Moore's Bridges and about twice greater for the lower one-third next above the depth of 900 feet than for the middle one-third.

---

* Annual Report Geol. Survey of N. J., 1898, page 122.

These two wells are approximately east and west of each other. The comparisons show that the lower portion of the Miocene beds dip about 100 feet between the two localities, or about 14 feet per mile eastward. Similarly the underlying Ripley Cretaceous beds dip some 200 feet or more, or about 30 feet per mile, likewise eastward.

Below we correlate the beds in these two wells, stratum for stratum. The depths at Lambert's Point are as marked on each specimen, all the specimens being described. Those noted at Moore's Bridges are also as they were marked when received, but have been selected from among numerous others at various intervening depths as most nearly resembling those from Lambert's Point.

	Depths at Lambert's Point.					Depths at Moore's Bridges.	
Yellowish sands . .	0 to	17 ft.,	equivalent to	specimens	from	0 to	18 ft.
Blue clay, ...	17 "	44 "	"	"	"	21 "	65 "
Gray micaceous sand with *shell* fragments, . . .	44 "	183 "	"	"	at		205 "
Greenish gray sandy clay, . .	183 "	191 "	"	"	from	260 "	285 "
Gray micaceous sand, ...	191 "	233 "	"	"	at	"	315 "
Fine sand and clay, ...	233 "	264 "	"	"	from	325 "	345 "
Gray clay, . . .	264 "	286 "	"	"	at		385 "
*Fine gray sand with *shell*, . . .	286 "	355 "					
Gray clay, ...	355 "	377 "	"	"	at		475 "
*Fine gray sand, .	377 "	397 "					
Dark gray clay, .	397 "	407 "					
Gray sand mixture of glauconite sand and *foraminiferal shells*,	407 "	526 "	"	"	at		625 "

---

*The specimens received from the depths marked 286 to 355 feet, 377 feet, and 397 to 407 feet wer too minute and unsatisfactory for correlation.

Excepting the first 50 or 65 feet, which probably represents the Pleistocene, the strata noted *above* are mainly Miocene in age.

The strata noted *beneath* represents the Cretaceous, and judging by the fossils, mainly the Matawan or Ripley division thereof. The Miocene interval of 150 feet between the depths of 475 feet and 625 feet at Moore's Bridges, which includes the great Miocene diatom bed, seems wanting at Lambert's Point. This indicates considerable unconformity between the Miocene and the underlying Cretaceous.

	Depth at Lambert's Point.		Depth at Moore's Bridges.
Small gravel, . .	526 to 534 feet,	equivalent to specimen at	735 feet.
*Rock stratum, .	534 " 540 "		
Gray clay, . . .	540 " 563 "	" "	" 755 "
*Rock stratum, .	563 " 564 "		
Gray clay. . . .	564 " 568 "	" "	" 765 "
*Rock stratum, .	568 to 603 "		
Ripley or Matawan *fossils* from, ...	563 " 608 "	equivalent to fossils from	715 to 780 feet
*Small gravel in coarse sand, . .	603 " 606 "		
Rock stratum, .	606 " 610 "		
Gray sand micaceous, exactly identical at both places, .	610 " 616 "	" " "	805 "

Sec. 2. Wells in Miocene Strata.

ARTESIAN WELL AT BRIDGETON.

Elevation, 40 feet; diameter, 6 inches; depth, 126 feet
Water rises within 66 feet of the surface.

Joseph W. Pratt furnishes the following record of strata in a well bored by him at the Cumberland county asylum, near the old fair grounds, at Bridgeton:

---

* There were no rock nor gravel specimens from the Moore's Bridges well with which to correlate these litholgically.

Surface and yellow gravel,	0	feet	to	12	feet.
Yellow loam and sand,	12	"	"	78	"
Sand, color of brown sugar,	79	"	"	88	"
White pebbly gravel,	88	"	"	92	"
Slightly water-bearing, at 70 to 92 feet.					
Light brown quicksand,	92	"	"	118	"
Open quality sand, color of brown sugar, *water-bearing*,	118	"	"	126	"

This well was finished with an 8-foot strainer at the base. The quality of the water is said to be excellent, and there is also said to be plenty of it, as a test was made, when 40 to 50 gallons a minute were pumped, this amount being up to the capacity of the pump used.

The location is not far from that of a well put down at the residence of Orlando Cook, on the *western* border of Bridgeton,* and which was abandoned at the depth of 90 feet, because of the small amount of water obtainable, which water was first noted at the depth of 80 feet. The same scant water-supply was found in this well at an equivalent depth—the surface at both wells being said to be of about the same elevation.

No specimens of the borings were preserved, and without these the writer would not, with present data in hand, venture to certainly determine the geological age of all the strata penetrated, but as the lowest of these are possibly Miocene, he includes it under the heading of "wells in Miocene strata." The more shallow well of 1893 was reported under the heading of "Wells in the Superficial Strata."

ARTESIAN WELL AT CEDARVILLE.

Elevation, 15 (?) feet; diameter, 3 inches; depth, 93 feet.
Water rises within 12 feet of the surface.

Haines Bros. report a well bored by them for John H. Diament, at Cedarville, Cumberland county, eight miles south of Bridgeton. Its depth is 93 feet. Haines Bros. say the material passed through was all white sand to the bottom, where a black clay was touched. Water was first found at a depth of 20 feet and continued the rest of the way down.

The black clay touched at the bottom was probably Miocene clay. The water-bearing sand is probably also of Miocene age, and if so, the horizon would seem to be the same as supplies wells at Weymouth (depth, 40 feet, elevation, 25 feet), and Mays Landing (depth, 196 feet, elevation, 20 feet).

---

* Erroneously stated to be at *East* Bridgeton in the Annual Report for 1893, page 418.

WELL AT GREENBANK, N. J.

Elevation 20 feet; depth, 54 feet
Water rises 10 feet above high tide.

This well is located on the banks of the Mullica river at the store of Wm. Sooy, who some years since furnished the writer the record below:

	Thickness	Total Depth.
Gravel and sand, with hard water, to	13 feet	= 13 feet
Clay,	20 "	= 33 "
Black clay,	5 feet to 12 "	= 45 "
Gravel with water to		54 "

It may be remarked that a *black tenaceous clay* outcrops at Herman City, also on the Mullica river, one mile westward.

ARTESIAN WELL AT SMITH'S LANDING.

Elevation, 30 feet; diameter, 6 inches; depth, 704 feet.
This well was prospected beyond this to the depth of 715 feet.
Water rises to within 17 feet of the surface.

During the summer Uriah White put down a well at the Atlantic county asylum, near to and south of Smith's Landing, the location being more accurately stated as at Dolphin station, on the branch railroad from Pleasantville to Somer's Point. The depth of the well as finished is 704 feet, though the boring was prospected beyond this to 715 feet, where the top of a clay stratum was found. The top of the water-bearing sands occur at 640 feet. The well is six inches in diameter and is finished at the base with a 4½-inch strainer 41 feet in length. This draws water from between the depths of 663 and 704 feet. The water rises to within 17 feet of the surface. When pumped at the rate of 100 gallons a minute the water level was lowered to 23 feet from the surface, but quickly rose again to 17 feet when the pumping was stopped. The water-horizon is the equivalent of that which we have heretofore designated as the 800-foot horizon at Atlantic City, which is four miles to the eastward, nearly directly on line with the natural dip of the beds.

Through the courtesy of the contractor and his assistants we have been furnished with a full series of the borings taken every 10 feet in depth all the way down. From an examination of this series, supplemented by considerable information verbally obtained, we make the subjoined record.

Loamy soil underlaid by yellow gravel,	0 feet to	15 feet.	Recent.
Yellowish sands, ranging from fine to very coarse sand and fine gravel,	15 "	" 173 "	Age (?)
Yellow sandy clay seams at 40 to 45 feet.			
Decidedly orange-colored coarse sand at 140 to 160 feet.			
Clay streaks at 161 to 173 feet.			
Dark clay,	173 "	" 180 "	Miocene.
Alternations of sands, clayey sands, and sandy clays all brownish in shade and varying from fine to medium in quality. No micro-organisms,	180 "	" 310 "	
Decidedly sandy clay at 280 to 300 feet.			
Nearly solid clay bed containing *diatoms* and some *sponge spicules* throughout,	310 "	" 570 "	
Sand with *shell*, 420 to 430 feet.			
Diatoms especially plentiful between 490 to 570 feet.			
Comminuted shell, 560 to 570 feet.			
Loose rock described as boulders, at		570 "	
Alternations of clayey sands and sandy clays; no diatoms nor other micro-organisms,	570 "	" 640 "	
Water bearing sands decidedly coarse at the bottom,	640 "	" 715 "	
Clay beneath,		715 "	

The upper or the great diatom bed of the Atlantic coastal plain Miocene deposits is 260 feet thick in this well, and occupies the interval between the depths of 310 and 570 feet. In this connection we may state that well-borings at Wildwood,*

---

* Annual Report Geol. Survey, N. J., 1894, foot of page 164, Diatom bed No. 4, at Wildwood.

N. J., and at Lewes,[*] Del., have revealed at those places a lower diatom bed within the Miocene and about 200 feet below the base of this bed. This second or lower bed probably exists beneath this locality and also Atlantic City, but at a still lower depth than the horizons (the 700 and the 800-foot Atlantic City horizons) that are utilized for water-supply, and for the same reason has therefore not been reached by the numerous borings along the coast from Brigantine to Avalon, these having been made only to the depths of these two (700 and 800-foot) water-horizons.

It was, however, probably penetrated by two extra deep borings at Atlantic City that were at first unsuccessfully made, so far as obtaining water was concerned, to the depths of about 1,100 and 1,400 feet in the early efforts to obtain water there, as stated in the Annual Reports for 1887, page 26; 1888, pages 72 to 75, and 1889, pages 89 to 99, the latter with an illustrated vertical section.[†] The existence, however, of this second or lower diatom bed was not then learned, probably for the reason that specimens of the borings covering this interval were not preserved.

ARTESIAN WELLS AT ATLANTIC CITY, N. J.

At The Traymore, ...	Depth, 830 feet
At The Waldorf-Astoria, . .	Depth, 837 feet.
At the Gas Works, ...	Depth, 790 feet.

Deep wells have been put down at Atlantic City during the past year at The Traymore, at The Waldorf-Astoria and at the Gas Works.

---

[*] Annual Report Geol. Survey, N. J., page 89, Marine Fossil Diatoms at Lewes, at the depths of 1,000 to 1,020 feet.

[†] Noted also with illustrated vertical section in Proceedings of the Academy of Natural Sciences, 1890, pages 132 to 147, Geology of Artesian Wells at Atlantic City, by Lewis Woolman.

Both of these wells afterward obtained water, one of them, on the meadows, by parting the casing and opening the 800-foot water-horizon, and the other, at the gas works, by withdrawing the casing a short distance and opening a water-horizon still deeper, but one the exact depth of which has not been certainly learned. In the Annual Report for 1889, its depth was stated to be at 1,121 feet, and in the Annual Report for 189-, this depth was revised and stated to be probably at about 925 feet. A deep well at Young's ocean pier, in process of boring as this goes to print and which has reached a depth of about 1,500 feet, shows, however, that probably neither of these statements is correct It is hoped this well, when finished, will reveal its true depth. This boring also shows that the records furnished the survey of the first two deep wells is more or less incorrect. An entire revision of the vertical section beneath the depth of 850 feet is needed, but must be left for the future, however.

From Uriah White, who put down all three of these wells, we have received data respecting them, which we report below, the succession of strata penetrated being, of course, identically the same as has been heretofore frequently noted in these annual reports for other wells at this locality. Those especially interested can consult these reports for the years from 1889 to 1898 inclusive.

At the Traymore.

Elevation, 10 feet +; diameter, 6 inches; depth, 830 feet.
Water rose to the surface, but did not overflow.
Was pumped 225 gallons a minute, lowering the water to 11 feet from the surface.

Uriah White, the contractor, furnishes the information tabulated above. The well draws from the 800-foot Atlantic City water-horizon.

At the Waldorf-Astoria, at Beach End of Ocean Avenue.

Elevation, 10 feet; diameter, 6 inches; depth, 837 feet.
Water rose to the surface, but did not overflow.
The well was pumped 140 gallons a minute, lowering the water 8 feet below the surface.

Uriah White also furnishes the information tabulated above. This well likewise draws from the 800-foot Atlantic City water-horizon.

At the Gas Works, Corner of Michigan and Arctic Avenues.

Elevation, 10 feet; diameter, 6 inches to 505 feet; 4½ inches to 720 feet; 3 inches to 790 feet; depth, 790 feet.
Water barely overflowed at the surface
Was pumped 100 gallons a minute, lowering the water to 20 feet from the surface.

This well had been sunk with a six-inch bore previously to 1888, by another well-driller, to the depth of 505 feet and abandoned.* Uriah White continued the boring the present year to the depth of 790 feet, finishing it at the bottom with a strainer 50 feet in length and procuring a satisfactory supply of good water from the "800-foot" Atlantic City Miocene water-horizon. The wells at Atlantic City vary in depth in accordance with the dip seaward and the depth to which they are continued into the water-bearing sand, which is about 60 to 80 feet thick. The variation in depth ranges from a minimum of about 750 feet on the meadows to a maximum of about 860 feet on the beach front.

---

* No record of this old well has heretofore appeared in these annual reports.

ARTESIAN WELL NO. IV, AT OCEAN CITY.

Elevation, 5 feet ÷ ; diameter, 8 inches ; depth, 830 feet.
Rock band, 2 feet thick, at 629 feet, below which the diameter was reduced to 6 inches
Water overflowed, but amount not ascertained.

There are now at Ocean City four artesian wells, all belonging to Ocean City Water Company and all drilled by Uriah White. This, the fourth well, was put down during the early summer. All the wells are located on the west side of the Pennsylvania Railroad Company's track, and are distributed between Eleventh and Fourteenth streets, each being a few hundred feet apart; this, the fourth one, being about 500 feet south of well No. III. The diameter of well No. IV is 8 inches to the depth of 629 feet, where a rock band about 2 feet thick was encountered, below which the boring was reduced to six inches. The well has a total depth of 830 feet and was finished with a 50-foot slotted pipe that answers as a strainer at the bottom.

The water overflows at the surface, but on account of the heavy and nearly continuous pumping from the other wells, its amount could not be ascertained. The beds penetrated, as should be expected, were essentially the same as in the former wells, for the stratigraphical record of which the interested reader is referred to the Annual Reports for 1892, 1893 and 1896.

We may, however, mention that in this well a black or very dark clay was observed at 300 to 330 feet, below which was a 40-foot bed of sand to the depth of 370 feet, where the top of the great 300-foot diatom clay-bed that occurs beneath the Atlantic coastal plain was met with.

ARTESIAN WELL AT SEA ISLE CITY.

Elevation 10 feet; diameter, 6 inches; depth, 825 feet.
Water rises within one foot of the surface.
Fossil mollusks at the depth of 795 feet.

In the spring of 1898 Uriah White finished the sinking of a six-inch well at Sea Isle City.

This well has a depth of 825 feet and is finished with a 70-foot strainer at the base. A rock stratum was met with at 690 feet, and the top of the water-horizon at 730 feet. The well has a natural overflow of 60 gallons a minute. The water-horizon utilized is probably the equivalent of the 800-foot Atlantic City Miocene horizon.

We have been favored by the contractor with samples of the borings. One specimen from the depth of 795 feet, a grayish, medium, coarse, free sand, without any mixture of clay, contains exceedingly great numbers of the shells of two small bivalves, with the nacreous lustre as well preserved as it is on the small clam shells that may now be picked up on the beach. The species, however, are different from those of the present day.

These shells have been referred to Dr. W. H. Dall, who writes as follows:

"One is an *Ervilia* not far from *E. concentrica* Gould, but a distinct species. The other is a *Crassinella*, but not, I think, the genuine *C. lunulata* Conrad, though allied to it. It is very like some I have named *lunulata* in the past, but I am now in doubt as to whether the determination was correct. Conrad's species came from Suffolk, Va., and as all the species are closely related, it will take a close study to determine them," for which he further states time is not now at command.

Associated with these bivalves were a *very* few univalve or gastropod shells, which time does not permit us to identify.

From a well at the same place, reported in the Annual Report for 1896, page 176, the same two specific forms of bivalves were obtained from the depth of 805 feet, doubtless representing the same bed. This shell-deposit is within the water-bearing sands, but toward their base.

ARTESIAN WELL AT MAHON RIVER, DEL.

Elevation 5 feet + ; depth 350 feet.
Water rises 16 feet above tide.

From I. A. Harrison, of Tilghman, Md., we learn that in the year 1897 he bored a well near the mouth of Mahon river, Delaware, on Delaware bay, to the depth of 350 feet, where he says he found "a hard sand almost like stone, which afforded an abundance of water of excellent quality, which flowed 16 feet above tide-level." He also furnishes the following descriptive record:

Sand and clay, surface to	**200 feet.**
Solid green clay,	**200 feet to 350 "**
Then hard sand, water-bearing.	

The water-horizon is doubtless in the Miocene.

In the Annual Report for 1893, page 401, there is a record of a well at this locality with a depth of only 206 feet, thus showing two water-horizons at this locality.

ARTESIAN WELL AT BOWER'S BEACH, DEL.

Elevation, 5 feet + ; diameter, 3½ inches ; depth, 500 feet.
Water at 240 feet that rises 2 feet above tide-level. Very little water lower than 240 feet.

I. A. Harrison also informs that he has bored a well at Bower's Beach, Delaware, about eight miles south of Mahon river. This location is on the Delaware bay, at the mouth of the Murderkill creek.

He states that at the depth of 240 feet he found water that rose about two feet above tide-level and that yielded, by pumping, about 20 gallons a minute. It is said this boring was prospected to the depth of 500 feet and that but very little additional water was obtained below the 240-foot horizon. The water-horizon of this well is probably in the Miocene. Had the well been prospected a short distance further, it is probable the horizon met with at Mahon river at the depth of 350 feet, as noted in the preceding record, would have been found.

FIVE ARTESIAN WELLS TWO MILES NORTHEAST OF MADISON, MD.

Elevation, 5 feet + (?) ; depth, 320 feet.
Wates rises about 4 feet above tide.

The locality of these wells is near Madison, Md., and about eight miles southwest of Cambridge and near Little Choptank bay, on the Chesapeake side of the eastern shore peninsular part of Maryland.

The wells were put down by I. A. Harrison, of Tilghman, Md., who furnishes from memory the following record, which may be regarded as approximately correct:

Sand,	20 feet =	20 feet.
Thin stratum of shells, hard packed.		
Sandy clay,	60 " =	80 "
Soft stone streak.		
Sandy clay,	10 " =	90 "
Harder stone streak.		
Sandy clay,	20 " =	110 "
Very hard stone streak.		
Clay,	190 " =	300 "
Sand, water-bearing,	20 " =	320 "

The water-horizon opened is doubtless the same as that developed by an artesian at Cambridge, at the depth of 360 feet, as incidentally noted in the Annual Report for 1890, page 275, last paragraph but one.

ARTESIAN BORING AT DELMAR, DEL.

Depth, 402 feet.

In the year 1885 the Delaware division of the Philadelphia, Wilmington and Baltimore Railroad Company had a well drilled at their station at Delmar, Del., to the depth of 402 feet, when the work was abandoned without having obtained a supply of water.

Of this boring the writer, in the early 90's, obtained, at the company's office, at Clayton, Del., copies of three records which had been separately kept by three of the company's civil engineers who had been interested in the work. No specimens, however, of the borings had been preserved, and until the writer came recently to study the record and specimens from a well four miles south, at Salisbury, Md., he was unable to harmonize the three records.

It is, however, now found that all three records are in substantial agreement and differ only in that the three observers each noted and described separate phases of the strata and at different depths.

Below we present a revised record compiled from the three records already noticed:

Fine sand at	48 feet.
Coarse sand,	48 to 85 "
Water at 80 feet.	
Sand,	85 " 136 "
White sand and soft sand (rock ?),	136 " 157 "
Black sandy clay,	157 " 168 "
Sand, gravel and pebbles; sand at top and bottom, reddish,	168 " 207 "
Light-colored bluish sand, very hard,	207 " 220 "
Fine sand,	220 " 264 "
Light gray clay,	264 " 306 "
Fine white *shells* at 300 to 304 feet.	
Hard sand,	306 " 341 "
Marl or clay with fine *shells*,	341 " 374 "
Sand,	374 " 386 "
Clay,	386 " 402 "

ARTESIAN WELLS AT SALISBURY, MD.

15 gang wells for water-works—Elevation, 5 feet; depths, 18 to 75 feet.
One well—Elevation, 5 feet; depth, 101 feet.
One well—Elevation 30 feet; diameter, 4½ inches; depth, 72 feet.
Yields, by pumping, 42,300 gallons a day.
One well—Elevation, 30 feet; diameter, 6 inches; depth, 267 feet.
The last named well was prospected to the depth of 424 feet.
Water overflows from the 101-foot well, having an elevation of but about
five feet, while from the wells with an elevation of thirty feet
it rises to within 3 to 5 feet of the surface

Salisbury, Md., is supplied with water "from a gang of 15 driven 6-inch wells to depths of 18 to 75 feet. They yield in all about 200 gallons a minute."* The level is about five feet above tide, while from about the same level "a deeper boring was made to 101 feet for lower waters, but the result was not satisfactory, because the water was strongly impregnated with mineral matters." *

During the year 1893, Dr. L. S. Bell put down for an ice factory, on somewhat higher ground, estimated at 30 feet above tide, two other wells, one of which was prospected much deeper, or to the depth of 424 feet from the surface, although this well was afterwards finished so as to draw water from about the depth of 267 feet. The other well at the ice factory reached the depth of 72 feet only.

Dr. Bell courteously furnished a full series of specimens of the borings from the second or more shallow well and a nearly equally full series from the first or deeper well from below the depth of 105 feet, together with quite complete stratigraphic data. From a careful study of these data and of the specimens from the two borings, we have compiled the following record, in which, wherever we use Dr. Bell's exact language, we enclose the same in quotation marks, and wherever we have inserted a word in his description we place the same in brackets.

	Thickness.	Total depths.
"Surface sand,"	6 feet,	6 feet.
"Dark clay,"	19 "	25 "
White sand,†	10 "	35 "
"Fine sand,"	9 "	44 "
"Sand gradually getting coarser and more yellow," . .	21 "	65 "
Fossilferous pebbles at 50 to 60 feet, is a *water-horizon*.		
"Hard pan, iron formation,"	2 "	67 "
"Light strata of white, sandy, loamy clay,"	1 foot,	68 "
"Iron (colored) sand," is a *water-horizon*, ...	25 feet,	93 "
Fine clayey sand, with lignite, ...	9 "	102 "
Fine gray sand, furnishes *pure water*, ...	14 "	116 "
"Blue sticky clay, strongly mixed with gray sand," .	19 "	135 "
"Fine gray sand, with water, which comes near the surface and seems to be colored by rotten wood," . . .	25 "	160 "
"Gray sand gradually getting coarser,"	25 "	185 "

---

*Bulletin 138, U. S. Geol. Survey, page 131. Artesian Wells, &c., N. H. Darton.

†Dr. Bell informs that this white sand occurred only in the 72 feet well and not in 424 feet well although the two wells are scarcely 25 feet apart.

	Thickness.	Total depths.
"Very coarse gravel mixed with much fine gray sand," . *Water-bearing.*	72 feet,	257 feet.
"Clay and fine sand full of small sea-shells," described in a letter received as "*Conch* and other *snail* and *clam shells*, but no oysters,"	6 "	263 "
None of these shells were received with the borings, having been previously given away.		
"Solid blue clay," containing much greensand or glauconite grains. "*Clam shells* frequent at 274 feet,"	87 "	350 "
Streak of gray, coarse gravelly sand at		350 "
"Clay mixed with fine black sand,"	5 "	355 "
"Black marl mixed with clay and gravel," decidedly glauconitic,	21 "	376 "
"Struck big cobble stones at 376 feet."		
Marl slowly changing to gray, gritty sand,	12 "	388 "
Small mollusks in the two last-named strata (see specific description in a later paragraph).		
Gray sand,	36 "	424 "
"Struck other cobblestones at 404, 410 and 420 feet."		

Dr. Bell writes that "there was a great deal of water in the wells at the ice factory at about 48, 80, 158, 214 and 250 feet. Also that the water-horizon at about 80 feet in the water-works wells was met with at 105 feet at the ice-factory, and that the latter is on ground about 25 feet higher than the former."

On studying carefully these two records (at Delmar, Del., and Salisbury, Md.), we find that the upper strata, say probably to the depth of about 185, or possibly to 200 feet, lie nearly level, while below that depth the beds dip decidedly toward the ocean. If we assume these underlying beds to strike northeast and southwest, which they probably approximately do, their distance apart, along the line of dip to the southeast, would be about four miles. As noted in the records, marl with shells occurs at Delmar between 280 and 332 feet, while at Salisbury marl with shells, probably the same bed, occurs at 350 to 388 feet, making a dip of 70 feet between the two points.

These facts, considered in connection with our knowledge respecting wells at Lewes, Del., and at Wildwood and Avalon, N. J., indicate that the uppermost beds of the Miocene in lower Delaware and in the Cape May peninsula dip seaward at the rate of about 17 feet per mile. This is somewhat less than our previous studies show to be the case along the coast, say from Ocean City and Atlantic City northward, where we calculate the dip at about 25 feet per mile.

Dr. Bell, in a letter, describes the shells noted above at 257 to 263 feet as "*conch and other snail shells and clams*," and states that there were no oysters.

The shells noted at from 355 to 388 feet were taken out by the writer from the borings received. They were mostly small, sometimes nearly entire shells, and at other times broken and very fragmentary. C. W. Johnson has identified the following forms, which, collectively, may be considered characteristic of the upper Chesapeake Miocene, or the equivalent of the St. Mary's fauna:

Teinostoma umbilicata, H. C. Lea.
Turritella plebeia, Say.
Turritella variabilis, Conrad.
Turritella alticostata Conrad.
Dentalium —— Sp. ?
Nassa peralta.
Crucibulum —— Sp. ?
Cardium laqueatum (?) Conrad.
Anomia —— Sp. ?
Solen ensiformis, Conrad.

From the same fossil-horizon we obtained a small otolith or ear-bone of a fish. Judging from the size of this otolith the fish to which it belonged was probably not over three or four inches in length. We are, however, unable to make out the species.

There were also small fragmentary specimens of a Crustacean, probably *Balanus proteus*, Conrad.

The nearest deep well suitably situated for comparison of strata, from which the writer has specimens of the borings, is at Lewes, Del. Here the top of the great 300 to 400-foot Miocene diatomaceous bed was met with at 407 feet. The specimens from Salisbury, as already stated, show, however, on microscopic examination, no diatoms. It is therefore probable that this well does not reach that bed. The clay at the depth of 402 feet at the bottom of the well at Delmar probably represents the top of the diatom bed, so that it seems quite possible (on calculating the dip) that had the well at Salisbury been prospected some 70 or 75 feet deeper, the top of the great diatom bed would have been found there likewise.

ARTESIAN WELL AT POKOMOKE CITY, MD.

Diameter, 2 inches ; depth, 105 feet.
Water rose 18 inches above the surface, or about 5 feet above high water.

In 1895 a trial well was drilled at Pokomoke City, of which specimens and some data were furnished the writer by W. J. Young, C. E. From these the following record has been compiled:

12 feet.	Sand and loam, to		12 feet.
3 "	Coarse yellow gravel, large as shellbarks, with plenty of water (surface water),	12 feet to	15 "
28 "	Fine blue clay,	15 " "	43 "
10 "	Clay with *shells*,	43 " "	53 "
15 "	Clay, with greater numbers of *shells*,	53 " "	68 "
27 "	Fine gravel and sand, not much water,	68 " "	94 "
1 "	Gravel and clay,	94 " "	95 "
11 "	Fine quicksand.	95 " "	105 "

Abundance of water at 97 feet.

TWO ADDITIONAL ARTESIAN WELLS AT POCOMOKE CITY, MD.

Depth of each about 290 feet.
One of these wells was prospected to 496 feet.
Diameter of each, 6 inches.

Five water-horizons, as follows:

"Good water" between the depths of	75 feet and	85 feet.
"Hard water" " " "	120 " "	123 "
Water utilized between the depths of	195 " "	225 "
" " " " "	247 " "	290 "
"Sulphur water" " " "	485 " "	496 "

During the present year, J. H. K. Shannahan, contractor, drilled for the Pokomoke water-works two much deeper wells at Pocomoke City, Md., than the one noted in the preceding record. From Norman M. Shannahan, in immediate charge of the work, we have received the following description:

Made ground to		15 feet.
Yellow and brown mixed clay,	15 feet =	30 "
Dark clay,	45 " =	75 "
Gray sand with good water, flowed 3 gallons a minute,	10 " =	85 "
Green clay,	35 " =	120 "
Coarse sand with water, which overflowed; pumped 60 gallons a minute. Water was very hard,	3 " =	123 "
Dark green clay,	63 " =	186 "
Gravel and *sea shells*,	3 " =	189 "
Sand rock,	6 " =	195 "
Light-colored coarse sand; when dry nearly white; contains *water* which flowed 45 gallons a minute and from which there was pumped about 150 gallons a minute—(salty),	30 " =	225 "
Dark green clay with some *sea shells*,	20 " =	245 "
Very hard fine-grained sandstone rock,	2 " =	247 "
Sand like that at 200 feet, only this had *sea shells* in it, also contained *water* of quality same as at 200 feet. Flowed 45 gallons and pumped about 175 gallons a minute,	43 " =	290 "
Light gray clay, like putty,	180 " =	470 "
Hard and soft marl beds,	15 " =	485 "
Coarse sand with water; flowed 50 gallons and pumped 100 gallons a minute. Strong with "sulphur,"	11 " =	496 "

The water of the last horizon not being at all potable the first well drilled was finished to draw from the two higher water-horizons at 195 to 225 feet and 247 to 290 feet. Afterward another 6-inch well was put down to the same two water-horizons. The two wells together, since being finished, flow about 150 gallons a minute. The water-horizon not used but noted above at about 85 feet is evidently the one reached by the well (depth, 105 feet) in the preceding record (see page 115) *as occurring at the depth of 97 feet.*

Sec. 3. Wells in Post-Miocene or Surface Strata.

TEST BORINGS AT PHILADELPHIA NAVY YARD, ON LEAGUE ISLAND.

Elevation, 10 feet +; diameter, 4 inches; depths, 25 to 38 feet.

During the latter part of the year 1898 a number of test borings were made for the United States government on League Island, preparatory to the construction of a dry-dock at the Philadelphia Navy Yard. These test borings were made near the location of a deep well (600 feet deep) at that place, of which records appear in the Annual Reports for 1896, page 114, and 1897, page 270, and which entered the Plastic clays and gravels of the Raritan formation at the depth of about 50 feet. As the record of the well then reported affords but scant information of the upper portion of the boring which penetrated the much more recent deposits that overlie the Cretaceous, and as through the kindness of C. C. Walcott, C. E., U. S. N., in charge of the engineering work, we have been furnished with a complete series of specimens from one of the test borings, as also several specimens from others of these test borings, we insert their record and particularize the results of our study of the same, in which we have been aided by the microscope.

We may, however, first state that these test borings reveal a depth of alluvium or quite recent mud or clay along the Delaware river front, on east side of the mouth of the Schuylkill, varying from about 25 feet to 38 feet, and that this alluvium contains, throughout its entire vertical extent, the siliceous cases or remains of single-celled plant organisms, known as diatoms. These diatoms present a mixed assemblage of fresh-water and marine species, among the latter being a triangular form, *Triceratium favus*, *Ehr*, which is found living to-day in the Delaware river at the latitude of Philadelphia, and also occurs in the muds on the river margin from the Breakwater northward to that city, but which the writer has been unable to find, either buried in the muds or living in the water, at Burlington. This particular fossil is indicative of deposits of quite recent geological age, say Pleistocene, and possibly also Pliocene; this Navy Yard alluvium being, however, certainly *decidedly late* Pleistocene.

At its base this marshy alluvium rests upon a coarse gravel with pebbles of considerable size, as revealed by the test borings and also by the dredgings brought up by a rotary dredging machine from the depth of 25 feet in the back channel. This heavy gravel, from an examination of its constituent pebbles, the writer deems to be Pensauken in age.

It may be interesting, for comparison, to note the depth of similar alluvial deposits at the debouchure into the Delaware of other tributaries, all of which exhibit a similar mixed assemblage of marine and fresh-water deposits. They are as follows:

Location.	Depths of marsh in feet.	Noted in Annual Reports for
Newtown Creek, Gloucester well record, . .	15*	1893, page 404
Pensauken Creek, ...	25 to 41	1898, page 111
Hog Island, at Tinicum Creek, ...	40	1896, page 115

We now insert the record in detail. The first column on the right gives the number of the borings in the order of the time when they were made, while the second gives the depth, in feet, of each specimen.

Result of Microscopic Examination of Late Pleistocene Alluvium (marsh mud) in Test Borings at Philadelphia Navy Yard, League Island, Pa.

No. of Well.	Depths of specimens.	
IX.	2 feet.	*Pinnularia* and some discoid diatoms.
IX.	2 "	*Eunotia* and circular discoid diatoms; also pin-head sponge spicules.
IX.	4 "	Diatoms, fairly plentiful.
IX.	6 "	Diatoms.
IX.	8 "	Diatoms, circular discoid forms noticeable.
IX.	10 "	Diatoms fairly plentiful in a fine, sandy, micaceous silt.
III.	10 "	Diatoms and a few sponge spicules.
IV.	10 "	Diatoms.
III.	12 "	No diatoms observed; silt quite sandy.
IX.	12 "	Diatoms, a few small discoid forms.
IV.	12 "	Diatoms, a few, with a few sponge spicules in fine silt.
IV.	14 "	Diatoms, a few.
IX.	14 "	Diatoms.
III.	14 "	Diatoms and sponge spicules.
IV.	16 "	A few sponge spicules; no other micro-organisms observed.
IX.	16 "	Diatoms. Large discoid forms plentiful.
III.	16 "	Diatoms.
V.	17 "	Diatoms.
IX.	18 "	Diatoms in a very fine sandy silt.
III.	18 "	Diatoms *Eunotia*, &c.; also a few sponge spicules.

---

* This boring was made quite close to the inner margin of the marshy flat; had it been farther out toward the stream and the centre of the marsh, it would probably have shown a still greater depth of alluvium.

No. of Well.	Depths of specimens.		
IX.	20 feet.	Diatoms.	
IV.	20 "	Diatoms, large discoid forms.	
III.	20 "	Diatoms.	
V.	21 "	Diatoms, a few.	
IV.	22 "	Sponge spicules; no diatoms seen.	
IX.	22 "	Diatoms.	
III.	22 "	Diatoms and sponge spicules.	
V.	23 "	Diatoms, *Triceratium favus*, &c.	
IX.	24 "	Diatoms.	
III.	24 "	Diatoms fairly plentiful.	
IV.	24 "	Diatoms fairly plentiful.	
V.	25 "	No micro-organisms seen—sand and very sandy clay.	
V.	29 "	No micro-organisms seen; very sandy, gravelly clay.	
IX.	26 "	Diatoms, a few.	
III.	26 "	Diatoms, a few in a mixture of gravel and sand, with a little clay.	
IV.	26 "	Diatoms.	
V.	27 "	No micro-organisms seen; very sandy clay.	
IX.	28 "	No micro-organisms seen; coarse sand with a little clay.	
IV.	28 "	Diatoms.	
IV.	29 "	Diatoms and sponge spicules.	
IV.	30 "	No micro-organisms; gravel and sand.	
IX.	30 "	No micro-organisms; sand, with a little clay.	
IX.	32 "	Diatoms, a few.	Coarse sand, with a little clay.
IX.	34 "	No micro-organisms.	
IX.	36 "	No micro-organisms.	
IX.	38 "	No micro-organisms.	

DUG WELL AT NORTHFIELD, ATLANTIC COUNTY, N. J.

Elevation, 30 feet; depth, 30 feet.

Early in 1898 a well was dug at Northfield for an Atlantic City organization, the Northfield Country Club. This well is located on the shore road near Northfield Station, on the Somer's Point branch of the Seashore Railroad, about one mile south of Smith's Landing.

The record is said to have been about as follows:

Yellow loam and gravel to	21 feet	= 21 feet.
Whitish clay,	5 "	= 26 "
Yellow sand and hard gravel, with water,	4 "	= 30 "

The water is said to be good and to stand 7 feet above the bottom of the well. The supply is entirely from the superficial sands or beds known as the Cape May formation.

ARTESIAN WELLS AT ABSECON FOR ATLANTIC CITY WATER-SUPPLY.

Elevation, 5 feet ±.
Two wells—Diameter, 4½ inches; depth, 100 feet.
One well—Diameter, 10 inches; depth, 70 feet.
Three wells—Diameter, 4½ inches; depth, 25 feet.

All the above wells were drilled by Uriah White.

In the Annual Report for 1892, pages 282 to 285, there is an extended notice with record of strata of a considerable number of wells with a depth of 24 feet. These wells have an elevation of about 5 feet above tide, and are located within the area occupied by a receiving basin, into which they naturally overflow.

Three additional wells of 4½ inches diameter have been sunk the past year within the same basin to the depth of 25 feet, the lower 6 feet being through a clay containing a mixed assemblage of marine and fresh-water diatoms of recent geological date. The water from these wells, as in those formerly sunk, flows directly into the basin.

Also, within the past year two other wells, 4½ inches in diameter, have been put down outside of the basins and at about the same level to the depth of about 100 feet, finding water in a coarse gravel, while one other 10-inch well has been put down on the top of the retaining bank of one of the receiving-reservoirs to the depth of only 78 feet, the elevation being about 15 feet.

Two series of the borings were received, one from one of the 4½-inch wells, depth 100 feet, and the other from the 10-inch well, depth 70 feet. Allowing about 10 feet for the difference in the elevation of the surface at the two wells, we have compiled the following stratigraphical record, the depths being from the elevation of 15 feet:

Heavy white gravel with fossiliferous pebbles, ...	0 feet to	18 feet.
Blue clay containing sponge spicules and *marine diatoms*, geologically very recent, ...	6 " "	25 "
Orange-yellow coarse sand, with water, ...	25 " "	70 "
Streak of white clay at		70 "
Gravel with large white pebbles and water at the base,	70 " "	100 "

Our recent study of the borings at this location confirm what we had formerly written in the before-mentioned Annual Report for 1892, and as we cannot now do better, we quote as follows from that report respecting the diatom bed and other associated and correlative facts:

"This section is especially interesting, since the marine diatoms noted are generally of so recent an appearance as to indicate at once to any experienced diatomist that the clay in which they are found was laid down not only comparatively recently, geologically, but also that it must be an entirely different stratum from the great 300-feet diatomaceous clay bed associated with the numerous deep wells in southern New Jersey.

"The conclusion, furthermore, seems irresistible that the heavy gravel with fossiliferous pebbles must have been placed on the top of the clay by a working over and re-depositing of the Quaternary yellow gravel and sands of the higher ground to the westward.

"The author has traced for three miles along the shores of the Great Egg Harbor river, near Mays Landing, a bed of clay containing a somewhat similar assemblage of diatoms, and likewise overlaid by gravels with fossiliferous pebbles.

"C. W. Coman has also furnished the Survey with specimens of clays from near the banks of the Maurice river, at Buckshutem, and from the banks of the Cohansey river, at Bridgeton, which, on examination under the microscope, also exhibited diatoms.

"The diatoms at these three localities were mixed marine and fresh-water forms, the marine predominating; but few fresh-water forms, however, were seen in the Absecon wells deposit. Strewn mounts of the diatoms from Absecon were submitted to C. H. Kain, an acknowledged authority upon their specific forms. He writes: "The species are almost exclusively marine; very rarely a fresh-water form is seen. I can discover no species not now to be found in the mud of Absecon marshes.

The abundance of circular [disc] forms, however, suggests a fossil deposit, although I can find no form which is now only found in the fossil state. I should suspect the deposit to be of comparatively recent formation. It greatly resembles in this respect the Bridgeton and Buckshutem deposits, although both of the latter contain a much greater proportion of fresh-water forms. The Absecon deposit may not be any more ancient, but probably it was not so much within the reach of fresh-water influences."

"These facts suggest some interesting relations between these various deposits. Additional careful investigation, especially in the field, will be needed, however, before their exact bearing upon each other can be fully defined.

"The wells at Atlantic City, after penetrating about 40 feet of beach sands and 10 feet of mud, the probable bottom of an old channel, enter a succession of gravel and clay beds which the author deems the equivalent of these at Absecon, a conclusion reached after careful study.

"So much of the Atlantic City section as may be needful to show its relation to the Absecon wells will now be given:

Record.					Age.
"Beach sand,		to	40	feet.	Very recent.
Mud *foraminifera* and *diatoms*,	40	"	50	"	
Heavy gravel, fossiliferous pebbles,	50	"	58	"	Recent.
Clay, *recent marine diatoms*,	58	"	63	"	
Heavy gray gravel, fossiliferous pebbles, fresh water,	63	"	72	"	
Clay, *recent marine diatoms*,	72	"	75	"	
Gray sand and gravel, water,	75	"	86	"	
Fine and coarse sand	86	"	105	"	Probably also recent.
Heavy gray gravel,	105	"	109	"	
Streaks of gray clay and sand	109	"	116	"	
Alternations of fine and coarse sands and gravels	116	"	265	"	Quaternary.
Most of the strata of this division are yellowish in color and contain no micro-organisms.					

"The similarity of the assemblage of diatoms in the clays from the Absecon wells with those noted above in clays at 58 to 63 feet, and again at 72 to 75 feet, considered in connection with the alternations of gravels with fossiliferous pebbles, suggests an identity of strata at the two localities.

"The water at the 24-foot wells at the water-works plant at Absecon is fresh and wholesome, as proved by its long use at Atlantic City. Its original source where it enters the sand that dips beneath this recent diatomaceous clay bed is probably not very distant. This water-horizon, however, under the beaches has not been considered satisfactory, and it or some horizons very closely related to it have been tried at a number of points between Atlantic City and Cape May. It was met with in Fifield's boring* at the depth of 84 feet, associated with a similar succession of beds as at Atlantic City. In the absence of specimens of the clays, however, the presence of diatoms, which most likely occurred there, cannot be positively asserted.

"Fresh-water springs, long known and used by boatmen for filling their casks, occur at various points in the marshes between the beaches and the mainland. One such may be noted on Barrel island, in the bay near Beach Haven, and another, until recently, on Peter's Beach, near Atlantic City. The storms, however, have washed away a large portion of this beach and buried this spring beneath the waters of the inlet. These springs are probably fed from this Absecon artesian horizon.

"The writer is inclined to class as of the same geological age with these recent diatom beds the gravels and sands below them to the depth, at Atlantic City, of at least 125 feet."

SHALLOW ASTESIAN WELLS AT ATLANTIC CITY, N. J., AT ATLANTIC CITY COOLING CO.'S PLANT.

Elevation, 5 feet ±; diameter, 4½ inches; depth, 93 feet.
Water rises barely to the surface

During the past year four wells have been put down, to the depth of about 93 feet each, into a water-bearing heavy gravel. The water obtained, being several degrees lower in temperature † than that from the deeper wells, is better adapted for the cooling and condensing purposes, for which the company requires a considerable amount of water.

---

* Annual Report, 1892, page 281.

† The temperature of the deeper wells varies from 58 to 62 degrees according to depth—that of the deepest wells being the highest. We have been unable to learn the exact temperature of these shallow wells above reported.

At the depth of 50 to 60 feet a bluish clay or alluvium was penetrated, which, on microscopic examination, we find to contain *diatoms* of fresh water and marine forms. The assemblage of *diatoms* shows this to belong to one of the most recent geological deposits along the coast, one of probably late Pleistocene age. Below the blue clay fairly heavy gravel was encountered which contains water that just rises to the surface. This gravel occupies the interval from 60 to 93 feet.

BORED WELLS AT SHINNECOCK HILLS, NEAR MONTAUK POINT, LONG ISLAND, N. Y.

Depth, 60 feet.

P. H. and J. Conlin inform "that they have sunk wells at Shinnecock Hills, near Montauk, and found gravel and water at 60 feet from the surface."

BORED WELL ON A HILL NORTH OF SIASCONSETT, TOWARD SANKATY HEAD, NANTUCKET, MASS.

Elevation, 70 feet; diameter, 4½ inches; depth, 103 feet.
Water rises within 70 feet of the surface.

This well is located at the cottage of S. Murray Mitchell and was bored by George H. Orcutt, who in 1896 furnished the above information, and who says that the boring was in sand throughout, and that he did not observe the occurrence of any sea shells.

ARTESIAN WELL AT LAUREL, DEL.

Elevation, 26 feet above mean low water.
Diameter 4 inches; depth, 115 feet.
Water rises within 19 feet 6 inches of the surface.
Yield, 110 gallons a minute.

During the summer of the present year a well was put down by J. H. K. Shannahan at Laurel, Del., to furnish that place with a public water-supply. From Charles S. York, C. E., we have received the following record:

Yellow clay,	2 feet	= 2 feet.
Light gray sand,	6 "	= 8 "
Yellow clay,	15 "	= 23 "
Coarse yellow sand ; yielded water, 10 gallons a minute,	40 "	= 63 "
Yellow clay, 20 inches, say,	2 "	= 65 "
Small flinty gravel ; yields water, 60 gallons a minute,	6 "	= 71 "
Yellow clay,	2 "	= 73 "
Small pebbly gravel, with water,	8 "	= 81 "
Yellow clay, 9 inches, say,	1 foot	= 82 "
Water-bearing sand, with pebbly gravel,	9 feet	= 91 "
Water-bearing sand,	14 "	= 115 "

The horizon 91 to 115 feet yielded 110 gallons a minute.

This well was finished with screens so as to draw from between the depths of 64 to 70 feet and of 72 to 85 feet.

ARTESIAN WELLS AT SEAFORD, DEL.

Two wells—Depths, about 65 feet each.
Elevation near high-tide level.
Overflow, at high tide, 15 gallons each per minute.
Overflow at low tide, very little

J. H. K. Shannahan reports having put down two wells at Seaford, Del., the location being a little above high-water mark and the depth of each about 65 feet. The wells were finished with screens so as to draw from between the depths of 53 and 65 feet.

This horizon is evidently the same as that supplying the wells of the preceding record at Laurel, seven miles southward.

IV. Wells Mostly in Northern New Jersey.

Sec. 1. Wells Reported by Stotthoff Bros.

The following 36 wells were put down the past year by Stotthoff Bros., who have courteously furnished the data respecting them.

Most of these wells are in northern New Jersey ; a few are, however, on Staten and Long Islands, N. Y., and a few others in

Pennsylvania, the latter mainly in the Delaware valley. The well at New Dorp, Staten Island, with a depth of 600 feet, is noticeable, since all below the depth of 28 feet was through serpentine.

Besides these the records of two other wells bored by them at Burlington appear with the wells classified under the heading "Wells in Cretaceous."

BORED WELL AT HUNTSVILLE, SUSSEX COUNTY, FOR E. E. HAWK.

Earth,	16 feet =	16 feet.
Limestone,	170 " =	186 "

Practically no water; not more than one-half gallon per minute.

BORED WELL AT HUNTSVILLE FOR W. J. YOUNG.

Sand,	95 feet =	95 feet.

Supply, 15 gallons per minute at 60 feet from the surface.

BORED WELL AT SPARTA FOR C. C. COX.

"Gray mixed rock or soft granite with flint and limestone, . . to 55 feet.

Supply, 5 gallons per minute.

BORED WELL AT BERNARDSVILLE FOR MISS M. APPLETON.

Depth 128 feet.

Yellow clay and loose stones to rock at		39 feet.
Gray rock, with seams of much softer yellow rock,	89 feet =	128 "

This well produces 35 gallons a minute at 29 feet below the surface.

BORED WELL AT BERNARDSVILLE FOR MISS S. F. CONDICT.

Depth, 224 feet.

Earth,	2 feet =	2 feet.
Gray rock,	222 " =	224 "

Supply, 7 gallons per minute at 140 feet from the surface.

BORED WELL AT BERNARDSVILLE FOR GEORGE B. POST.

Depth 621 feet.

Earth and loose stones to rock,	26 feet.
Dark gray rock,	595 "
	621 "

Supply, 3½ gallons a minute.

BORED WELL AT FLEMINGTON FOR GEORGE C. PEDRICK.

Depth to solid rock,	15 feet	= 15 feet.
Red shale,	36 "	= 51 "

Supply, 18 gallons per minute.

BORED WELL AT FLEMINGTON FOR FLEMINGTON WATER CO.

Earth	4 feet	= 4 feet.
Gray and blue rock. "very seamy, similar in character to what is called blue jingler,"	164 "	= 168 "
"Vein of clay" (?)	8 "	= 176 "
Red shale,	229 "	= 405 "

Supply, 107 gallons a minute at 161 feet from the surface.

BORED WELL AT READINGTON, FOR JOHN E. HOAGLAND.

Earth,	20 feet	= 20 feet.
Red shale,	67 "	= 87 "

Supply, 15 gallons per minute.

BORED WELL AT THREE BRIDGES FOR FARMERS' DISPATCH CO.

Earth	6 feet.
Cased and cemented to	30 "
Balance red shale to total depth of	94 "

Supply, 15 gallons per minute.

BORED WELL AT LIBERTY CORNERS FOR FRANK BALLENTINE.

Earth,	5 feet =	5 feet.
Red shale,	104 " =	109 "

Supply, 7 gallons a minute at 65 feet from the surface.

BORED WELL AT SOMERVILLE AT CHILDREN'S MEMORIAL HOME.

Depth, 152 feet.

This well was drilled 8 inches in diameter to the depth of 51 feet and then cased with a six-inch pipe and cemented. The boring was then continued beyond this entirely in red shale to a total depth from the surface of 152 feet. The yield is 25 gallons per minute at 125 feet from the surface.

BORED WELL AT GOODMAN'S CROSSING, L. V. R. R.

Earth,	33 feet =	33 feet.
Red shale,	73 " =	106 "

Supply, 20 gallons per minute at 40 feet from the surface.

BORED WELL AT MAYWOOD FOR MRS. C. M. GOMEZ.

Earth	15 feet =	15 feet.
Red shale.	104 " =	119 "

Supply, 18 gallons per minute at 43 feet from the surface.

BORED WELL AT MAYWOOD, BERGEN COUNTY, FOR JOHN ENGLISH.

Red sandstone,	46 feet.

Supply, 10 gallons a minute.

BORED WELL AT TRENTON FOR R. M. JONES.

Earth.	3 feet =	3 feet.
"Hard but fine grained red and blue sandstone,"	140 " =	143 "

Supply, 10 gallons a minute at 125 feet from the surface.

BORED WELL AT MARTINSVILLE, SOMERSET COUNTY.

Diameter, 8 inches; depth, 114 feet.

Earth,	10 feet =	10 feet.
Cased and cemented to keep out surface water to		50 "
Balance, blue and red shale to a total depth of		114 "

Supply, 15 gallons a minute at 60 feet from the surface.

BORED WELL AT UNION, UNION COUNTY, FOR C. H. JOHNSON.

Earth,	23 feet =	23 feet
Red shale,	153 " =	176 "

Supply, 10 gallons per minute at 60 feet from the surface.

BORED WELL AT LINDEN FOR THE P. R. R.

Depth, 122 feet.

This well was drilled 8 inches in diameter to the depth of 40 feet and then cased with a 6-inch pipe and cemented to prevent surface drainage.

The boring was continued beyond this to a total depth of 122 feet, producing 15 gallons a minute at 22 feet from the surface.

BORED WELL AT ELIZABETH FOR WILLIAM HEILICH.

Earth and hard pan,	58 feet =	58 feet.
Red shale,	158 " =	216 "

Supply, 10 gallons a minute at 125 feet from the surface.

BORED WELL AT PASSAIC FOR CHARLES E. BELL.

Earth,	26 feet	= 26 feet.
Red sandstone,	36 "	= 62 "

Supply, 20 gallons a minute at 26 feet from the surface.

BORED WELL AT PASSAIC FOR ISADORE BRAVEMAN.

Earth and quicksand,	46 feet	= 46 feet.
Red sandstone,	101 "	= 147 "

Supply, 14 gallons a minute at 27 feet from the surface.

BORED WELL AT PASSAIC FOR MOORELAND BROS.

Earth, stones and sand,	52 feet	= 52 feet.
Red sandstone,	168 "	= 220 "

Supply, 10 gallons a minute at 60 feet from the surface.

TWO BORED WELLS AT PASSAIC FOR THE BOTANY WORSTED MILLS.

Diameter of each, 8 inches ; depths, No. 1, 402 feet : No. 2, 558 feet

	No. 1.	No 2.
Sand and gravel,	20 feet.	35 feet.
Quicksand,	30 "	7 "
Clay and sand to rock,	42 "	52 "
Sandstone rock,	310 "	464 "
Total depths,	402 feet.	558 feet.

Well No. 1 was bored last year (1898).

BORED WELL AT PASSAIC FOR A. EHRHART.

Earth and sand,	35 feet	= 35 feet.
Red sandstone,	115 "	= 150 "

Supply, 10 gallons per minute at 88 feet from the surface.

BORING AT NEW DORP, STATEN ISLAND, N. Y., FOR CHARLES F. SCHMEIDT.

Earth,	28 feet =	28 feet.
Soapstone, soft [Serpentine],	572 " =	600 "

No water.

BORED WELL AT NEW DORP, STATEN ISLAND, N. Y., FOR WILLIAM ARNDT.

Sand and gravel, ... 85 feet.

This well produces 10 gallons a minute at 68 feet from the surface.

BORING AT BURDETTE, N. Y., FOR FARMERS' DAIRY DISPATCH.

Earth,	58 feet =	58 feet.
Gray sandstone or flaging,	236 " =	294 "

No water found. "Gas in the layers at 250 to 270 feet."

BORED WELL AT WOODSIDE, LONG ISLAND, N. Y., FOR THE CITIZENS' WATER CO.

This well has a depth of 227 feet and enters Gneiss rock at 138 feet. A detailed record appears on page 80 in its proper place with the records of other wells on Cretaceous.

BORED WELL AT WHITESTONE, LONG ISLAND, N. Y., FOR GEORGE KNEUPERT.

Depth, 96 feet.

Commenced in dug well at a depth of		16 feet.
Clay,	40 feet =	56 "
Quicksand,	14 " =	70 "
Medium coarse gravel, water-bearing,	26 " =	96 "

This well was finished with a screen and produces 10 gallons a minute at 60 feet below the surface.

BORED WELLS AT FAIRFIELD, CONN., FOR MRS. O. B. JENNINGS.

Well No. 1—Sand and gravel,	39 feet	= 39 feet.
Gneiss rock,	10 "	= 49 "

Supply, 60 gallons a minute at 9 feet from the surface.

Well No. 2—On nearly the same level, but 350 feet from well No. 1.

Earth and sand,	42 feet	= 42 feet.
Gneiss rock,	16 "	= 58 "

Supply, 60 gallons a minute at 6 feet from the surface.

BORED WELL AT EASTON PA., FOR VEILES BREWERY.

Diameter, 8 inches ; depth, 500 feet.

Earth,	31 feet	= 31 feet.
"Limestone,"	469 "	= 500 "

Supply, 105 gallons per minute at 43 feet from the surface.

BORED WELL AT BETHLEHEM, PA., FOR T. C. CAFFREY.

"Hard pan,"	30 feet	= 30 feet.
Loose yellow sand, with clay,	16 "	= 46 "
Yellow sand,	20 "	= 66 "

Supply, 35 gallons a minute at 27 feet from the surface.

BORED WELL AT ROSE GLEN, PA., FOR J. N. MEGARGEE.

Earth,	11 feet	= 11 feet.
Mica rock,	88 "	= 99 "

Supply, 10 gallons a minute at 28 feet from the surface.

BORED WELL AT SEIGFRIED, PA., FOR THE LAWRENCE CEMENT CO.

Rock, "all cement stone" to . . . . 194 feet.

The well produces 10 gallons of water a minute ; the boring, however, was not completed.

BORED WELL AT YARDLEY, PA., FOR FRANK ANDERSON.

Earth,	15 feet	= 15 feet.
Red shale,	30 "	= 45 "

Supply, 3 gallons per minute.

BORED WELL AT YARDLEY, PA., FOR R. C. BELVILLE.

Sand and loose stones,	37 feet	= 37 feet.
Red sandstone,	21 "	= 58 "

Supply, 15 gallons per minute at 35 feet from the surface.

Sec. 2. Bored Wells Reported by P. H. and J. Conlan.

The following records of wells put down during the year by P. H. and J. Conlan have been courteously furnished by that firm. Among them the well records at Summit and vicinity are especially interesting, and supplement those reported last year by C. L. Tribus at Chatham and Madison, in that they demonstrate a phenomenal and abundant overflow of water in this region at depths of from 80 to 150 feet in gravel overlying the Newark red sandstone rocks, and apparently overlaid by an impervious bed of clay. (See note by H. B. Kümmell, second paragraph, next page.)

TWO BORED WELLS NEAR SUMMIT, BETWEEN SUMMIT AND CHATHAM.

Depth of each, 120 feet.

Near Summit, N. J., remarkable water-bearing strata were encountered in the glacial drift. Two wells were sunk near the old mill, on the Passaic river, midway between Summit and Chatham. Both wells are 120 feet deep. Glacial till and clay formed the overlying beds, beneath which a water-bearing bed of gravel, resting upon the red shale, was struck. The water rose 10 feet above the surface. Owing to the large amount of free ammonia present, the water was unfit for use and the wells have been closed.

TWO BORED WELLS THREE MILES NORTHEAST OF SUMMIT, ALONG CANOE BROOK.

Depths 90 and 125 feet.

Two wells were put down along Canoe brook about three miles northeast of Summit. The first well was 125 feet deep and the second 90 feet, the latter with an 8-inch hole. The overlying strata were mainly till and clay, beneath which the water-bearing gravel bed was struck. The water rose 25 feet above the surface. One million gallons per day is the estimated flow from these two wells. The water is excellent.

(All four of these wells, together with those near Chatham reported by Mr. Tribus in the Annual Report for 1898, are in the basin of the glacial lake Passaic, and the impervious clay beds overlying the water-bearing gravels may in part be the lacustrine deposits. H. B. K.)

WELL IN NEWARK, N. J., FOR THE CELLULOID MFG. CO.

Depth, 827 feet

"We put down a 10-inch well for the Celluloid Mfg. Co. to a depth of 827 feet; it is 100 feet to rock and there is a 10-inch hole in the rock. The well yields a very large quantity of water, over 200 gallons per minute. It is situated on Ferry and Fillmore streets, at their works."

WELL IN NEWARK, N. J., FOR CAULEY, CLARK & CO.

Depth, 400 feet

"In the Newark meadows, near the Lehigh Valley Railroad track, we sunk a well for the firm of Cauley, Clark & Co. We went down to a depth of 400 feet, obtaining but a very poor supply of water. It is 225 feet to the red sandstone, which is the prevailing rock all along that district in Newark."

WELL AT HARRISON, N. J., FOR PETER HAUCK & CO.

Depth, 400 feet.

This well, which we put down for Peter Hauck & Co., is situated on the east side of the Passaic, and is 400 feet deep. It is 135 feet to rock, the remainder being in soft red shale. The yield is about 100 gallons per minute. The water is of a very excellent quality. Harrison avenue and 5th street.

WELL AT KEARNY, N. J., FOR THE LINOLEUM WORKS.

Depth, 335 feet.

The depth of this well is 335 feet; 35 feet to rock. A 12-inch pipe is sunk to rock, which is a red sandstone. The water is very good in quality and the yield is over 150 gallons per minute.

WELL AT WEST ORANGE FOR E. V. CONNETT.

Depth, 384 feet.

The well for this firm was sunk to a depth of 384 feet and is 8 inches in diameter. It yields about 100 gallons per minute. The water is of excellent quality. It is 50 feet from the surface to rock, which consists of red shale and sandstone.

TEST BORINGS TO ROCK ALONG THE PASSAIC RIVER.

We have recently made several test borings along the Passaic and at the Dundee dam for the U. S. Engineer Corps, and find that the rock lies about 20 feet from surface at the dam, and 50 feet from surface at the Passaic bridge of the Erie Railroad. Those tests were made with a view of finding the depths to rock incidental to making the Passaic river navigable as far as Paterson.

WELL AT PASSAIC FOR THE OKONITE CO.

Depth, 492 feet.

We sunk this well to a depth of 492 feet. It is 110 feet to rock, which is red shale. The yield is about 60 gallons per minute, and the water is excellent.

TWO WELLS AT PASSAIC FOR THE PATERSON PARCHMENT PAPER CO.

Well No. 1—Depth, 1,000 feet.
Well No. 2 (not finished)—Depth 400 feet.

The first well we sunk for the Paterson Parchment Paper Co. was 1,000 feet deep; pipe was sunk to rock, 55 feet. Well yields a very small quantity of water. We are at the present time sinking a second well for the same company and have already drilled to a depth of over 400 feet. So far we cannot give full account, as well is only nearing completion.

WELL AT PASSAIC FOR ACHESON, HARDEN & CO.

Depth, 352 feet.

About a half-mile north of the paper factory we have just completed a well for Acheson, Harden & Co. The well is 352 feet deep; rock is 75 feet from surface. It is a remarkably good well and yields about 100 gallons per minute, while the water is of an excellent quality.

TEST BORINGS AT PASSAIC FOR THE GARA MILLS.

Depth to rock, 65 feet.

We also made test borings for the Gara Mills and found rock to be 65 feet from the surface, and the water seemingly of a good quality.

WELL AT [illegible] FOR J. [illegible] STRATTON.

Depth [illegible] feet.

At [illegible] we sunk a well for J. [illegible] Stratton, east [illegible] [illegible] through a thick stratum of [illegible] [illegible] water was obtained and the well is now used.

TEST BORINGS AT RAHWAY FOR MERCK & CO.

Depth [illegible] feet.

We [illegible] made some tests at Rahway to the depth of [illegible] feet [illegible] we drilled wells for the Pennsylvania Railroad Co. at their water-works. The rock is the usual kind found between Paterson and Trenton, that is, red shale.

BORED WELL AT JERSEY CITY FOR THE GREENVILLE BREWING CO.

Depth 64 feet.

In Jersey City, on the west side, near Newark bay, we sunk a well for the Greenville Brewing Co. to a depth of 64 feet and encountered the blue trap rock of the Palisades; no water was obtained.

WELL AT [illegible] ISLAND, SOUTHERN END OF NEWARK BAY AND NEAR ELIZABETH.

Depth 200 feet.

[illegible] Townsend & Downey we sunk a well 200 feet [illegible] and met with very peculiar strata, consisting [illegible] rock, interspersed with layers [illegible] to a depth of 200 feet, but found [illegible] the metamorphosed shales over-[illegible] [illegible] H. R. K.

BORED WELL IN NEW YORK CITY AT BOULEVARD AND 72D STREET.

Depth, 700 feet.

This well was put down for W. E. D. Stokes, and was drilled to a depth of 700 feet in gneiss rock with micaceous strata, and the yield is about 25 gallons per minute. The water is of a hard quality.

WELL AT ROCKAWAY, L. I., N. Y., FOR WM. S. ROGERS.

This well we sunk for Wm. S. Rogers, at Rockaway, L. I., and is a remarkably good one. The water was found in great abundance in sand and gravel near the surface. The quality is good.

Sec. 3. Wells at Jersey City.

Two wells are reported by the Joseph Dixon Crucible Co. as having been put down at their works at Jersey City.

Well No. 1.—1,205 feet yields 22 gallons per minute.
Well No. 2.— 400 " " 28 " " "

No report was made of the strata penetrated, but they were probably glacial drift and red shale and sandstone.

WELL AT POMPTON FOR J. D. STRATTON.

Depth, 200 feet.

At Pompton, N. J., we sunk a well for J. D. Stratton, east of railroad station, 200 feet through a close stratum of blue rock. Very little water was obtained and the well is not used.

TEST BORINGS AT RAHWAY FOR MERCK & CO.

Depth, 100 feet.

We have made some tests at Rahway to the depth of 100 feet, near where we drilled wells for the Pennsylvania Railroad Co. at their water-scoops. The rock is the usual kind found between Paterson and Trenton—that is, red shale.

BORED WELL AT JERSEY CITY FOR THE GREENVILLE BREWING CO.

Depth 64 feet.

In Jersey City, on the west side, near Newark bay, we sunk a well for the Greenville Brewing Co. to a depth of 64 feet and encountered the blue trap-rock of the Palisades; no water was obtained.

WELL ON SHOOTERS' ISLAND, SOUTHERN END OF NEWARK BAY AND NEAR ELIZABETH.

Depth 200 feet.

For the firm of Townsend & Downey we sunk a well 200 feet deep, 55 feet to rock, and met with very peculiar strata, consisting of beds of a yellow, hard rock, interspersed with layers of black slate. We drilled to a depth of 200 feet, but found no water. (These are probably the metamorphosed shales overlying the Palisade trap-sheet.—H. B. K.)

BORED WELL IN NEW YORK CITY AT BOULEVARD AND 72D STREET.

Depth, 700 feet.

This well was put down for W. E. D. Stokes, and was drilled to a depth of 700 feet in gneiss rock with micaceous strata, and the yield is about 25 gallons per minute. The water is of a hard quality.

WELL AT ROCKAWAY, L. I., N. Y., FOR WM. S. ROGERS.

This well we sunk for Wm. S. Rogers, at Rockaway, L. I., and is a remarkably good one. The water was found in great abundance in sand and gravel near the surface. The quality is good.

Sec. 3. Wells at Jersey City.

Two wells are reported by the Joseph Dixon Crucible Co. as having been put down at their works at Jersey City.

Well No. 1.—	1,205	feet	yields	22	gallons	per minute.
Well No. 2.—	400	"	"	28	"	" "

No report was made of the strata penetrated, but they were probably glacial drift and red shale and sandstone.

PART III.

Chlorine in the Natural Waters of the State.

By WILLIAM S. MYERS.

Chlorine in Natural Waters of the State.

By WILLIAM S. MYERS.

The well-known significance of chlorine in potable waters is of sufficient importance to render the adducement of theories relating to it unnecessary. Sanitary authorities are in agreement as to the value and importance of the chlorine factor in the formation of a judgment as to the quality of a water-supply. As supplementary to the Geological Survey's studies of the water-supplying of the State, analyses have been made with a view to securing data for a map of the State, showing the normal chlorine in its potable waters in each locality throughout the State. Satisfactory progress has been made and valuable data secured during the past ten months. Considerable data are yet to be obtained and the variation in chlorine content is so wide as to well warrant the continuance of the work; and a map, at least a preliminary one, can soon be made.

The data, as published, will be useful, it is hoped, to sanitarians; and it will invite the attention of every one interested in water-supply; a subject of evergrowing importance to all communities.

As an illustration of the use of the map, for example: Should examination show the chlorine content of a given water to be, say, ten parts per million, and the normal for that place be known, from our map, to be several parts less per million, some explanation of the difference would be necessary, otherwise the quality of the water would be regarded as impaired. In the absence of adequate explanation, sewage or other contamination might properly be suspected.

If the sources of pollution could not be discovered and removed, the water should be rejected. On the other hand, should the content fall below the normal, or equal it, the fact would be strong evidence in favor of pronouncing the supply to be a good one.

In short, the data which we are securing will serve, we believe, to render the results for the chlorine determination in waters of New Jersey of more value and importance than ever before. Instead of more or less conjecture as to the significance of the figures for chlorine, we shall have more rigorous and exact interpretation of results, and consequently more trustworthy opinions.

As to artesian supply and waters not regarded as strictly surface-waters, a separate table of analyses is given. These are to be taken as a separate study, but only after more complete data can be had of surface supplies.

In regard to the surface supply, when rivers and small streams are recorded, the particular places will be indicated when the map is published.

The data for total solids in the surface waters will be interesting to those who study the Surface Geology of the State, and the amount of annual erosion and weathering may be considered in this connection.

Chemical sanitary analyses are given of certain waters, and these will be studied in connection with the analyses for total solids and chlorine. Taken as a whole, the standards for this State may be found to be somewhat different from other localities. The data are as yet not complete enough to enable one to draw inferences of a trustworthy nature. As our data increase we expect that careful comparative studies will throw some additional light on the relations of surface, ground and artesian supplies.

Referring to the general subject of water-supply, it may be well to note that in a recent station report the Vermont official chemists state that, of the large number of waters examined by them during a period of five years, 20 per cent. of the spring waters examined were impure. Of the wells, 50 per cent. were impure. Of the pond and stream supplies, 41 per cent. were impure or unfit for use.

In view of the steady increase in the population of our State and of our adjoining great cities, and in view of the steady increase in *per capita* daily consumption of water, it is difficult to overestimate the importance of conserving our present supply. Equally essential is the completion of the Survey's investigation of the whole subject as a matter of vital importance to our commonwealth.

All the samples were taken with great care; some by Professor Smock, State Geologist; some by Professor S. R. Morse; some by Mr. W. C. Hawley; others by Mr. Kümmel, assistant State Geologist, and Mr. Smith of the Survey. A number of the waters were also sampled by the writer.

RUTGERS COLLEGE CHEMICAL LABORATORY, DECEMBER 1, 1899.

WILLIAM S. MYERS,
Department of Chemistry.

Table of Analyses of Surface-Waters.

	Port Jervis, N. Y. Delaware River.	Delaware River. Delaware Water Gap. (159)	Spring Holmdel. Monmouth County.
Total Solids, ...	36.40	48.00	. . .
Chlorine, ...	1.20	2.90	6.80
	Clinton Reservoir. (167)	Macopin. (168)	Intake Reservoir. (169)
Total Solids, ...	63.20	74.80	60.00
Chlorine, ...	2.80	2.60	2.70
	Lake Hopatcong. (184)	Hurd's Hopatcong. (172)	South River at Spotswood.
Total Solids, ...	45.00	90.00	25.00
Chlorine, ...	2.30	2.40	5.30
	Lake Mashipacong. (175)	Sand Pond. (176)	Swartswood Lake. (177)
Total Solids, ...	16.00	48.00	71.00
Chlorine, ...	0.80	1.20	2.10
	Culver's Lake. (178)	Big Flatbrook. (179)	Spring, Culver's Gap. (180)
Total Solids, ...	78.00	30.00	38.20
Chlorine, ...	0.80	1.10	1.20
	Bevan's Spring. Peter's Valley. (181) ?	Red Medina. 1½ mi. S. W. Wallpack. (182)	Budd's Lake. (183)
Total Solids, ...	194.00	25.00	100.00
Chlorine, ...	2.40	0.70	2.40

	Matchopanix River. (186)	Ambrose's Brook at Bound Brook. (187)	Robinson's Brook. (188)	Morristown City. (190)
Total Solids, . .	55.00	90 00	167.00	110.00
Chlorine, . . .	6.40	5.60	6 20	2.90

	Somerville, Raritan River. (157)	Trenton, Delaware River. (161)	Lambertville, Delaware River. (160)	East Millstone, Millstone River. (193)	Stony Brook. (192)
Total Solids, .	98.00	80.00	78.00	63.00	75.00
Chlorine, . . .	5.20	4.80	3.70	6.60	5.90

Table of Detailed Analyses of Surface Waters Submitted for Chemical Sanitary Analysis.

	Delaware River at Delaware Water Gap.	Delaware River at Lambertville.	Delaware River at Trenton, Calhoun St.
Total Solids, ...	48.00	78.00	80.00
Total Organic and Volatile Matter, ...	8.00	38.00	40.00
Total Salts, Mineral Matter,	40.00	40.00	40.00
Chlorine, ...	2.90	3.70	4.80
Free Ammonia, ...	0.04	0.11	0.12
Albuminoid Ammonia, . .	0.07	0 05	0.08
Nitrogen in Nitrates, . . .	0.12	0.005	0.01
Nitrogen in Nitrites, . . .	0.004	0.005	0.01

	Raritan River, Somerville.	Clinton Reservoir near Newfoundland, N. J.	Intake Reservoir.	Macopin Lake.
Total Solids, ...	90.00	63 20	60.00	74.80
Total Organic and Volatile Matter, ...	42.00	11.20	28.80	28.00
Total Salts, Mineral Matter,	56.00	52.00	31.20	46.80
Chlorine, ...	5.20	2.80	2.70	2.60
Free Ammonia, ...	0.16	0.14	0.12	0.09
Albuminoid Ammonia, . .	0.04	0.06	0.19	0.23
Nitrogen in Nitrates, . . .	0.02	0.00	0.00	0.00
Nitrogen in Nitrites, . . .	0.01	0.00	0.00	0.00

Table of Analyses of Artesian Well Waters.

	Brigantine.	Lakewood. 600 feet. (150)	Lakewood. 600 feet. (151)	Asbury Park. 600 feet. (152)	Asbury Park. 1,100 feet (153)
Total Solids, . . .	125.00	119.80	108.60	126.00	136.00
Chlorine, ...	10.20	3.90	4.91	5.90	7.10

	Atlantic City. " Consumers' pumping station." (154)	Atlantic City. Gen'l Supply. (155)	Hotel Dennis. 850 feet. (156)	Camden. Artesian. (158)
Total Solids, ...	128.80	42.00	150.00	32.00
Chlorine, ...	9.82	13.30	10.12	5.73

	Marlton Well. (171)	East Orange. (170)	Jersey City and Dixon Ave. (174)
Total Solids, ...	200.80	238.00	216.00
Chlorine, ...	6.80	16.10	40.52

Detailed Analyses of Waters Submitted for Chemical Sanitary Examination—Artesian Wells.

	Lakewood I.	Lakewood II.	Asbury Park I.	Asbury Park II.
Total Solids, ...	119.80	108.60	126.00	136.00
Total Organic and Volatile Matter, ...	39.30	18.10	28.40	40.00
Total Salts, Mineral Matter,	80.50	90.50	97.60	96.00
Chlorine.	3.90	4.91	5.90	7.10
Free Ammonia, ...	0.03	0.05	0.04	0.03
Albuminoid Ammonia, . .	0.05	0.07	0.08	0.05
Nitrogen in Nitrates, . . .	0.10	0.12	0.02	0.02
Nitrogen in Nitrites, . . .	0.25	0.25	0.02	0.04
Depth of Wells, ...	600 ft.	600 ft.	600 ft.	1,100 ft.

	Brigantine Co. Brigantine.	Atlantic City. General Supply.	Atlantic City. Consumers' Station.	Atlantic City Hotel Dennis.
Total Solids, ...	125.00	42.00	128.80	150.00
Total Organic and Volatile Matter, ...	25.00	8.00	38.40	46.00
Total Salts, Mineral Matter,	100.00	34.00	90.40	104.00
Chlorine, ...	10.20	13.30	9.82	10.12
Free Ammonia, ...	0.24	0.04	0.24	0.06
Albuminoid Ammonia, . .	0.00	0.04	0.04	0.03
Nitrogen in Nitrates, . . .	0.00	0.0001	0.00	0.06
Nitrogen in Nitrites, . . .	0.005	0.0000	0.00	0.00
Depth of Wells, ...	700 ft.	30 ft.		856 ft.

	Camden Supply.	Marlton Town Well.	East Orange General Supply.
Total Solids, ...	32.00	200.80	238.00
Total Organic and Volatile Matter, ...	16.00	58.00	86.00
Total Salts, Mineral Matter,	16.00	142.80	152.00
Chlorine, ...	5.73	5 90	16.10
Free Ammonia.	0.05	0.06	0.08
Albuminoid Ammonia, . .	0.07	0.02	0.08
Nitrogen in Nitrates, . . .	0.02	0.10	8.00
Nitrogen in Nitrites. . . .	0.00	0.00	0.00
Depth of Wells			

PART IV.

THE MINING INDUSTRY.

I. Report on Iron Mines,

By GEORGE E. JENKINS.

II. Notes on Copper Mines,

By HENRY B. KÜMMEL.

Review of the Iron Mining Industry.

By GEO. E. JENKINS, C. E.

During the past year the iron-mining industry has experienced one of the most remarkable revivals in its history, for at no time were there fewer mines in operation and prices so low as at the close of last year's report. At that time pig iron was commanding only ten dollars per ton at the furnaces, and New Jersey ore sold at an average of two dollars per ton. In January of this year, after a long period of extremely low prices, pig iron began to advance, and in less than six weeks the price had risen more than one hundred per cent. A consequent rise in the price of iron ore took place, and has continued, so that the average price of ore to-day is about three dollars and one-half per ton. All the mines that were in operation last year have put forth every effort for an increased yield, and many of the enterprises which had been closed by low prices have resumed operations, and several sales of mining property have taken place at something like the old-time prices. Many leases have also been made, and, on the whole, the industry is probably in as satisfactory a condition as ever was known in its history.

The question of the concentration of the large quantities of lean ores has also received closer attention, and there certainly is a wide-field open for investigation along this line. The concentrating plant at Hibernia, in addition to the one at Edison, has been operated most of the year on the lean refuse from the Hibernia vein and Beach Glen ore. At the close of last year the following mines were in operation: Hurd, Richard, Edison, Lower Wood, and Wharton, on the Hibernia vein, and the new Sterling Slope, at Irondale. To this list is to be added, as now in operation, the Ringwood mines, Green Pond, Beach Glen, Ford, Weldon, Kishpaugh, Oxford mines and the Mt. Hope mines, and the following notes are a more extended review of these several enterprises as well as references to a number of promising prospective ore properties.

The Iron-Mining Industry.

HURD MINE, HURDTOWN, N. J.

The owners of this property did some prospecting with a diamond drill in search for new shoots of ore, but nothing very promising was secured from the tests, and the results of this work were reported last year.

In the spring of 1899 a lease was made with Pilling & Crane, of Philadelphia, and they have been mining, from old workings, about two hundred tons of ore per month, and in addition have been exploring for new shoots of ore. This work consists in the driving of a cross-cut from the old working, known as the "Clay shaft," in a southeast direction toward the old Hurd shoot of ore for a distance of 120 feet, where a deposit of ore was cut, but it proved to be small and to have been previously worked upon. A shaft 209 feet deep was sunk so as to come down upon the offset, and a cross-cut or drift is now being driven along the throw of the offset toward the large deposit of ore presumed to have been broken off from the old deposit.

RICHARD MINES.

During the year the work on the very remarkably large deposit of ore which has been developed in the past four years has shown that the size and extent of the deposit has not yet been determined. The large quantity of ore found on the foot-wall side of the vein has during the past year been duplicated by the discovery and working of an equally large deposit on the hanging-wall side. The drifts driven in an easterly direction along the hanging-wall have shown ore from fifteen to twenty feet thick, and as much as could be safely removed has been taken out, but a very large amount still remains.

The ore in the foot-wall in No. 2 mine has been blasted down, and carried with it the small "horser," or rock, so that the distance from wall to wall is very near one hundred feet, and consequently too wide a gap to keep up by timbering.

The drift six hundred feet east of No. 2 shaft has gone forward and pressed through the pinch or roll in the deposit, and from present indications the vein is returning to its regular dip.

No work has been done in No. 3 shaft during the past year, because of the unsatisfactory condition of the shaft near the surface, and all the energy possible has been devoted to the sinking of the new slope, known as No. 5.

The product of the mine has been curtailed about 36,000 tons, owing to the shut-down of the No. 3 shaft.

In the No. 1 mine some explorations were made on both the foot-wall and hanging-wall side of the vein, and ore was discovered which ran about ten feet thick in both drifts.

No sinking has been done during the past year, as it will take at least two years to remove the ore standing in sight on the foot and hanging walls.

The No. 5 slope, which is to be the main outlet of the mine, is now down 700 feet, and at the 500-foot level a cross-cut 110 feet long was driven to the Mount Pleasant vein, and a deposit eight feet thick was cut. The drifts east and west are now being planned, and in all probability ore will be mined from this part of the vein before the year 1900 closes.

The slope known as No. 6, which was planned to strike the Mount Pleasant vein, has been put down 550 feet and "holed through" to the present easterly working on this vein. This will put an end to the long "tram" of more than a thousand feet to Slope No. 1, through which the ore now finds an outlet to the surface.

A large amount of money is being expended in the introduction of new machinery, consisting of a nest of boilers having a capacity of 1,500 horse-power, and a large, latest-improved Ingersoll Sergeant air-compressor of 750 horse-power. A new pumping system will also be installed in No. 5 slope, and a modern hoist-way and equipment will all add to a very decided increase in the ore tonnage of this property.

MOUNT HOPE MINES.

The property of the Mount Hope Mining Company was purchased early in 1899 by the Empire Steel and Iron Company of New York City, and during the year the working in the Elizabeth mine has been unwatered and about 3,000 tons of ore removed from the western end of the mine adjoining the Teabo property. A new shaft which was put down to the face of the eastern stope from the tunnel level has been opened to surface, and this shaft will give improved facilities for removing the ore.

The ore mined was found on analysis to contain:

Metallic iron, ...	61.822
Silica, ...	6 700
Lime, ...	1.600
Magnesia, ...	trace
Sulphur, ...	"
Manganese, ...	"
Aluminum, ...	1 50

This is the richest of the five veins of ore existing on this tract.

The deepest working in the Elizabeth vein is 195 feet, and the deposit has been worked 200 feet along the vein in its northast southwest trend. The width of the vein is from 4 to 6 feet. The Taylor mine and the Side Hill mine have not yet been freed from water, but these two mines will be pumped out during the coming year. The workings in the Taylor vein are 576 feet along the vein, and the present ore-shoot has a height, from the top to the bottom, of 240 feet and an average thickness of 10 feet. The Side Hill vein is 480 feet deep to the bottom working, and the ore-shoot is 192 feet high and average 6 feet thick.

The Brennan vein and one other vein are both small, and pay to work only when prices are high.

The Hickory Hill ore-deposits have not been worked for some years, and some plan will be fixed upon to give this property a thorough test. It is the intention of the present operators to make this property yield at least 100,000 tons of ore a year.

NEW STERLING SLOPE AND HURD MINE.

The work during the year has consisted in developing the ground between the eastern offset and the Hurd workings. The old Hurd slope has been pumped out and a drift driven to intersect the old workings in Hurd mine, thus affording much needed relief in the way of ventilation, and enabling a change in the pumping arrangements which will reduce the present water-lift 185 feet. The amount of water is 60 gallons per minute, and it is all pumped by steam pumps.

On No. 5 level, in driving toward Hurd mine, a large body of ore, 9 feet wide, 60 feet high, was opened upon, and in No. 6 level the vein is 6 feet wide. On No. 8 level, in the drifts east of the offset, the vein showed a width of 12 feet of clear granular ore.

The Sterling slope was sunk 30 feet, mostly in barren ground, but the sink is to be put down 60 feet or more in order to test for a lower shoot of ore underlying the old No. 13 shoot.

These developments show what may be expected under the old Hurd slope, and adds considerable encouragement to the operators of this and adjoining property—the Orchard mine.

BEACH GLEN MINES.

The prospecting work carried on by the Beach Glen Mining Company in the year 1898 was stopped after a few months, and a lease made to Joseph Wharton, who has been operating the mine for the purpose of concentrating the ore in the works at Hibernia. The method of mining consists of open cutting, as the deposit is nearly thirty feet wide. The material, as it is mined, yields 30 to 40 per cent. of iron, and the concentrate is 60 per cent. The material crushes and separates well, and, as it is a Bessemer to start with, the final product is very low in phosphorus.

The mill was put in operation during the summer of 1899, and 3,750 tons of concentrates obtained from the refuse rock of Hibernia vein. The Beach Glen ore has been used only in the latter part of the year, and about 900 tons of crude material put through the mill, yielding 400 tons of concentrates, which ran 60 per cent. in metallic iron and .009 phosphorus.

HIBERNIA MINES.

The group of mines along this deposit consists of the following:

THE LOWER WOOD MINE.

As was stated in last year's report, the amount of work done on this property is very limited, but as it is the outlet for all the ore mined from the adjoining Church or Crane lot, it is of considerable interest and value to the operators on this account. The work for the year in actual mining has been confined to the Church or Crane lot, and it consists of the driving of stopes No. 19 and No. 20 toward the De Camp line to the eastward and sinking on No. 21 level. This is the deepest working on the Hibernia vein, and is 851 feet below tunnel level and 268 feet below sea level. The width of the vein in the present stopes is about thirteen feet, but there is more or less rock in the vein, and it is not at all regular, being very "bunchy." The ore-shoots are lenticular in form and have a pitch of about 27 degrees to the northeast.

CHURCH OR CRANE MINE.

This mine lot owned by the North Reformed Church, of Newark, N. J., and leased by the Andover Iron Company, was purchased by the lessees during the past year and has been operated through the Lower Wood Mine.

DECAMP MINE.

The owners of this property have not had any mining done since 1890, but during the year 1899 Mr. Joseph Wharton became the owner, and the mine will, without doubt, be a producer next year.

UPPER WOOD MINE.

The Glendon Iron Company formerly operated this mine, but during the year Mr. Joseph Wharton secured the title to the property, together with the Glendon mine lot, from the receiver of the Glendon Iron Company. The underground railroad tunnel is being driven in the foot-wall rock so as to connect with the shafts on the Upper Wood and DeCamp properties, and the mine no doubt will be in operation next year.

WHARTON MINE.

At no time in its history has this mine been so great a producer as during the past year, and the future is most promising. During the year every available stope has been worked and these nine stopes have yielded a large tonnage of ore. In addition to the regular stoping a sink of 50 feet was put down and the ore body continued to show the same regularity of width.

The improvements in the mine plant, made note of in last year's report, have been completed. and two well-equipped hoistways are now available, through which the mine's product is hoisted to surface.

The new shaft on the eastern end of the property has been sunk an additional depth, but no great quantity of ore has been discovered. At a depth of 105 feet a shoot of ore was cut, but it lacked continuity and soon cut out. It is the purpose to continue the sinking and "hole" through to the drift which is being driven eastward to intersect the shaft, thus giving an additional outlet for the eastern end of the mine. The recent purchases made by Joseph Wharton now give him control of 3,300 feet along the Hibernia vein and practically consolidating the whole mining interest in one operator. This will certainly lead to valuable results and increase the product of one of the most persistent ore-deposits in New Jersey.

GREEN POND MINE.

For almost twenty years the Green Pond mines have been idle, principally because of legal difficulties and the inability of the conflicting interests to get together upon some satisfactory basis. In 1898 The Carterette Steel Company, of 31 Nassau street, New York city, began to acquire interest, and the whole tract of the Copperas mine is now owned by this company. The mine has been pumped free from water and a new plant is being erected with which to actively work the mine.

The several lines of attraction across this tract have been opened upon by shallow test-pits, but the work has been done without definite aim or plan in mind, and hence no very satisfactory data is at hand from which to draw accurate conclusions. The workings in Slopes Nos. 1 to 6 have been carried deep enough to give some idea as to the length, width and continuity of the ore body. Slope No. 1 is the deepest working, being 210 feet vertical and 360 feet on the angle of the slope. The deposit is shown to be 70 feet high and from 20 to 25 feet thick, but the material in both the bottom of the slope and overhead carries ore, and no defined cap or bed-rock has yet been found.

Opening No. 3 is 74 feet to the northeast of No. 1, and the ground between these two openings is ore, so that practically the two openings are made in the same shoot of ore. The bottom of No. 3 is 70 feet below the outcrop, and the slope is 170 feet long. At the face of the breast the workings are 60 feet high and 20 feet thick. Nos. 4 and 5 are openings of shallow depths, but large quantities of ore were mined by the previous operators from these two openings. The foot-wall in all these openings is clean, but the hanging-wall is not, and the amount of magnetite in the mass would indicate that the true wall has not been found. The deposit was from 20 to 25 feet wide. The results from the magnetic-needle observations, together with the information gained from test-pits along the out-crop, show this deposit of ore to be continuous to the northeast. There is very little water to contend with and very little timbering is necessary, thus making fixed mining charges very light.

The vein to the northwest, as well as the one to the southeast, has been worked only to a very limited degree, but ore of varying width has been found to exist. The ore from the main deposit is a dense magnetite, high in sulphur and so low in phosphorus as to pass the Bessemer limit. The property has always been looked upon as a most promising deposit, and the work now installed will be watched with great interest.

FORD MINE.

There has been some work upon this property, under the direction of Isaac Hance, of Dover, but it has been confined to recovering ore above water-level and cobbing the refuse ore-heaps from previous operations.

OXFORD MINES.

The Empire Steel and Iron Company purchased and has operated this property during the year 1899.

On July 1st, work was begun in repairing the furnace and pumping out the mine. Only the Washington Mine and Slope No. 3 have been put in working order, and Slope No. 3 is the only one through which ore was mined. In Slope No. 3 the workings are 700 feet long and an east and west stope. On the west stope the vein is 4 feet wide, but the eastern stope has widened out to 10 feet of ore, and a product of over 80 tons per day is being taken out.

FELLOWS AND QUEEN MINES.

The Fellows Mine has been purchased and a lease secured on the Queen Mine by this company, and these mines are both being put into mining shape. Neither of these two mines produced any ore in 1899, and the condition of the workings has not changed since last reported upon, just before they suspended operations owing to the low prices then in command.

KISHPAUGH MINE.

The firm of Pilling & Crane re-opened this mine under lease during the past summer and have been mining about 250 tons of ore per month. The present workings are all on the Cook farm. The depth of the workings and the extent of the deposit are the same as noted in the report of 1896. But the ore is not as rich in metallic iron and is higher in phosphorus and sulphur than what was found in the more shallow workings on the Kishpaugh farm, as is evidenced from the following analysis:

Metallic iron,	48.516
Phosphorus,	.042
Sulphur,	.930

RINGWOOD MINES.

The activity of the iron business has had the effect of re-opening the Ringwood mines, and the two large shoots of ore worked before the mines were closed are producing ore. The product is sold in market, and the most of it has been used at the Pequest Furnace, by Joseph Wharton, lessee.

As a result of the study of the mining enterprises the facts are very prominently brought out that many of the deposits which have been idle for years past were not exhausted, but were closed principally by reason of the remarkably low prices that have been in command.

The acquisition of many of the mining properties by one individual or corporation, such as has been taking place during the past year, will certainly result in a reduction of operating expenses, and will ultimately be beneficial to the general mining interests of the State. In view of the revival of mining industry, and for the purpose of directing the attention of those seeking iron-ore properties, the following list of mines is republished, with such information as could be gathered in reference to the ownership, size of deposit and accessibility of product to points of shipment, etc.

DALRYMPLE MINE, SOUTHWEST OF DOVER, RANDOLPH TOWNSHIP.

The developments made upon this property have thoroughly tested the deposit, and a continuous vein of more than 500 feet in length, and averaging four to five feet of ore, was worked by the last operators. The high royalty and distance from the railroad are the two items of expense which closed the mine. With these out of the way, the property would be a most promising one. The following is an analysis of ore as shipped:

Metallic iron,	54.064
Silica,	18.00
Phosphorus,	.25
Sulphur,	trace.

BROTHERTON MINE, RANDOLPH TOWNSHIP, MORRIS COUNTY.

This property was last worked in 1882, and the parties now controlling it are negotiating a lease.

BLACK HILLS MINE.

The Dickerson Succasunna Mining Company renewed operations here in the fall of 1899. Several of the pits have been pumped out and preparations are being made for active mining. The previous work showed that there are four small veins and the deepest is only 100 feet. The material was rich in iron and very low in phosphorus.

ORCHARD MINE.

Some negotiations are now under way through which this mine will probably be leased and put in operation. The developments on the adjoining property of the New Jersey Iron Mining Company throw considerable light upon the future prospect of this mine, and afford encouragement to the owners.

ERB AND SCRUB OAKS OR DELL MINE.

The large body of ore known to exist on these properties owned by the Andover Iron Company is probably one of the best ores in New Jersey for concentration. The magnetite is found associated with a gangue made up principally of feldspar of a granular structure which crushes easily and is in every way, so far as its physical structure goes, well adapted for separation and concentration of the magnetite. The general run of the ore is about 40 per cent., and very low in phosphorus.

Negotiations are now under way for a lease to a party of capitalists, who propose opening the property and constructing a concentrating plant. The shipping facilities are of the best, as the mine is accessible to two railroads and canal.

HOFF MINE.

The Chester Iron Company operated this mine for a long term of years, but finally gave up the lease, and in 1885 and 1886 it was operated by Oram Hance & Co. There are two veins and the works are not leased. The property is worthy of more careful attention.

ALLEN MINE.

Now owned by Joseph Wharton, and some work is to be done in hopes of finding the remarkable body of ore which has been developed on the adjoining property. A careful study of the Richard mine underground workings, in connection with the Allen workings, will surely throw some light on the probability of finding the ore body on this property.

HIGH LEDGE MINE.

The analysis of the ore from this mine shows it to run 58 to 60 per cent., and the property is worthy of consideration at the hands of parties looking for iron ore.

DEKAY FARM, VERNON TOWNSHIP.

Observations by magnetic needle show a well-defined line of attraction along the strike of the rock, and here and there an outcrop of ore. A small test-pit was put down about 6 feet and a deposit of ore of workable size was uncovered. The following is an analysis of an average of the vein. The high percentage of titanium and silica, and the leanness of the ore, operate against it as a very promising mining property:

Metallic iron,	45.75
Silica,	31.40
Phosphorus,	.11
Sulphur,	.41
Titanium,	2.81

Hematite Ore.

The quantity of hematite ore, in comparison with the magnetic deposits in New Jersey, is of very limited area, but there are some localities where large bodies of this ore have been worked, notably the one at Beattystown. Some prospecting shafts were sunk during the past year, and ore in paying quantities found at a depth of about 20 feet from surface. It averages 40 per cent. of metallic iron, and, if the heavy stripping charges could be eliminated, the property would develop into a valuable one. A modified plan of the "long wall" system of coal mining, which has been used so successful at the Kishpaugh mine, is worthy of careful consideration. The property is close by good hipping facilities and the royalty asked is not excessive. The product of the mine in times past was as high as 4,000 tons per month. Some carbonate of iron was discovered at the bottom of the mine about the time the mining was closed down, but its extent was not determined.

Other hematite deposits which have yielded very considerable ore in times past are the old Pochuck mine near MacAfee, in Sussex county, and the several openings along Marble mountain, near Phillipsburg.

The Zinc Mines.

The New Jersey Zinc Company has operated its mines at Franklin Furnace, during the year, to their full capacity, and a large sum of money has been spent for the erection of a new concentrating plant of a daily capacity of 1,000 tons. The old mill at the Parker shaft, which has been in operation all the year, has a capacity of 500 tons. These two mills are intended to handle product from all the company's mines, both at Franklin Furnace and Sterling Hill, and the entire zinc product, from this district, is passed through the concentrating mill. The quantity of zinc ore mined has been larger than ever before and the future is as promising as ever.

The high prices in the zinc market have stimulated search for new deposits and on the Neighbor farm, near Vernoy station, in Hunterdon county, High Bridge Branch of C. R. R. of N. J., some work has been done in the hope of finding a paying deposit. The work consists of the sinking of a shaft in the limestone and the discovery of some zinc ore in the shape of "blende." The amount found has not been very considerable and it is in isolated bunches without any well defined line of continuity. The developments had not been carried along very far, but, at the time of our visit, the prospect was not very encouraging.

Analyses of New Jersey Iron Ores.

A knowledge of the chemical constituents of the iron ores used in a modern blast-furnace has become a very important factor in the management of such enterprises, and the Geological Survey in previous reports has published numerous analyses of the ores from the different mines in the State for the purpose of throwing all the light possible upon the value and economic use of the ores. The following collection of analyses, which has been placed at the disposition of the Survey by Mr. B. F. Fackenthal, President of The Thomas Iron Co., is published by his consent and with the hope that the information will be of value to the general iron-mining industry.

MATTISON OPENINGS NEAR ANDERSONTOWN, HUNTERDON COUNTY.

Sampled by Mr. Fackenthal; tested in the Hokendauqua Laboratory, March, 1886.

Silica,	30.15
Titanic acid,	Trace.
Metallic iron,	35.42
Phosphorus,	.006
Sulphur,	4.03

Other analyses furnished by Dr. Mattison showed 37.37 and 37.39 per cent. metallic iron.

HAGER MINE, HUNTERDON COUNTY.

Durham Iron Works found:

Titanic acid,	7.02	5.64	4.09
Phosphorus,	.19		
Silica,	6.64		
Metallic iron,	56.39		

VANSYCKLE'S, OR CHURCH MINE.

Contains .31, .38 per cent. of vanadic acid.

PETTY MINE, NEAR BLOOMSBURY.

Sample taken from 25 or 30 tons on dump, shows:

Metallic iron,	54.37
Phosphorus,	.02
Sulphur,	None.
Manganese,	.18
Silica,	14.87
Lime,	2.32
Magnesia,	5.31
Alumina,	.40
Titanic acid,	None.
Oxide of nickel,	.63

Magnetic Ore.

Mr. Fackenthal will comfirm analysis of the above ore for nickel. Property belongs to J. C. Cougle, Bloomsbury, N. J.

LEBANON MINE.

Owner claims to have 1,200 tons on dump at mines.

Silica	20.40	14.185
Titanic acid,	.47	
Metallic iron,	41.50	45.075
Phosphorus,	1.66	1.625
Sulphur,	2.74	3.634

South of New Jersey Central road. The property belongs to the estate of D. K. Hoffman, 1½ miles from Lebanon, N. J.

BEDELL MINE.

Operated and owned by Cooper & Hewitt.

Metallic iron,	34.72	34.93
Silica,	29.69	29.54
Lime,	9.14	10.09
Magnesia,	3.10	2.89
Alumina,	6.41	5 84
Phosphorus,	.008	.012
Sulphur,	.584	.380
Titanic acid,	.31	.21
Manganese,	.35	.34

BEEMER MINE.

Analyses made by Cooper & Hewitt, Durham Iron Works, 1886-1887:

	Blue.	Red.	Red.
Metallic iron,	41.10	54 23	
Phosphorus,	.135	.078	.10
Sulphur,	2.958		

LITTLE MINE.

Owned by Fellows. Sometimes called "Fellows" Mine. 531 cars mined by the Thomas Iron Company during 1893 shows:

Metallic iron,	56.29
Silica,	7.94
Phosphorus,	.103

The Thomas Iron Company found in a shipment of 375 cars of ore from this mine in 1891 an average analysis of 55.34 metallic iron, which included ten cars of unwashed ore in the shipment.

In July, 1891, a shipment of 25 cars showed the highest iron found by the Thomas Iron Company, which was 62.25 per cent. metallic iron. The lowest analysis was found in two cars of washed ore in 1891, which only gave 37.94 per cent. metallic iron.

QUEEN PROPERTY.

343 cars shipped to Thomas Iron Company during 1892 shows 55.29 per cent. metallic iron; 16 cars shipped to Hokendauqua (Thomas Iron Company), February 11, 1893, showed:

Metallic iron,	55.12
Insoluble,	9.81
Phosphorus,	.229

Sample from stock-house at Hellertown, Thomas Iron Company, 1893:

Metallic iron,	54.35
Manganese,	1 264
Phosphorus,	1.52

SHOEMAKER MINE, BELVIDERE.

125 cars to the Thomas Iron Company, October, 1893, shows 46.73 per cent. metallic iron. Other shipments to the Thomas Iron Company show:

Metallic iron,	51.42	46.48	51.87	50.05
Silica,	8.85			
Phosphorus,	1.048			
Manganese,	.17			
Alumina,	3.86			
Lime,	1.68			
Magnesia,	.18			

RAUB FARM, NEAR BUTTZVILLE.

Fine Ore.

Metallic iron,	33.80
Silica,	24.82
Phosphorus,	.192
Manganese,	1.836

Hard Ore.

Metallic iron,	63.87
Silica,	2.97
Phosphorus,	.118
Manganese,	.512

This property contains zinc-blende and has been noted in previous publications of the New Jersey Geological Survey.

OSMUN MINE.

Shipments to Cooper & Hewitt, four carloads.

Metallic iron,	58.302	55.73
Phosphorus,	.033	.065
Manganese,	1.084	

LITTLE MINE.

Little ore, all black, was shipped to Cooper & Hewitt.

Metallic iron,	67.54
Silica,	1.20
Lime,	.31
Alumina,	.74
Magnesia,	.51
Phosphorus,	.02
Sulphur,	.08
Titanic acid,	Trace.
Manganese,	.90

BROTHERTON MINE.

Samples tested by Booth, Garrett & Blair, for Pullman & George, show 0.11 per cent. of phosphorus.

JOHN H. SLACK PROPERTY.

Brown hematite, 2½ miles east of Bloomsbury, N. J. Shaft 8½ feet deep, of which 5½ feet is through ore. Ore in bottom of the shaft. Shipped from near Central Railroad of New Jersey.

Analyses of ore sent to Hokendauqua, Pa.:

Metallic iron,	44 33
Silica,	21.31
Phosphorus,	.17
Manganese,	06

CHARLES THATCHER PROPERTY.

Brown hematite. Between Stewartsville and New Village, N. J., on D., L. and W. R. R.

Metallic iron,	43.64

FORD MINE.

Shipped to Thomas Iron Company during 1899.

Metallic iron,	53.89
Sulphur,	.498
Phosphorus,	.319

Other tests show:

Metallic iron,	52.76	51.45	46.87	49.72

Roasted magnetic ore from Mt. Arlington, N. J., sent to Thomas Iron Company by O. W. Davis, August 20th, 1899.

Metallic iron,	43.18
Silica	21.43
Phosphorus,	.213
Sulphur,	.783

Dalrymple ore shipped by Mrs. Richard May to Thomas Iron Company during 1900. Dump at mine sampled by L. C. Bierwirth.

Metallic iron,	58.61
Phosphorus,	.296
Sulphur,	.026

EDISON.

1,000 tons Edison briquettes shipped to Thomas Iron Company, January, 1899.

Metallic iron,	62.83

MARCUS SAYRE PROPERTY, NEAR EDISON, (?) N. J.

Sample sent during May, 1899, by M. S. Higbie.

Metalli irocn,	40.58
Silica,	35.34
Phosphorus,	.326
Sulphur,	.106
Titanic acid,	2.27
Copper,	.080

Notes on Copper Mines.

By HENRY B. KÜMMEL.

The recent rise in the price of copper has attracted renewed attention to the copper deposits of New Jersey. These occur chiefly in the red shales and sandstones of the Newark formation, nearly always in close proximity to the trap-sheets, or dikes. Some of these localities were opened and ore mined as far back as colonial days, and in a few cases the ore was shipped to England. For many years the low price of copper has rendered it impossible to work these low-grade ores at a profit and the mines have all been closed. In many cases so long a time has elapsed since they were worked that the dump-piles are overgrown with vegetation and the tunnels are filled with fallen rubbish. With the increased price of copper and the modern methods of handling and reducing ores, whereby material formerly thrown away is utilized, it may be possible in some cases to work profitably these low-grade deposits.

SCHUYLER MINE, ARLINGTON.

This mine is the oldest of the copper mines in the State, and among the earliest mining enterprises in the country. It has been worked more or less frequently since 1719, but for the past thirty years nothing had been done, until a few months ago when a party of Boston capitalists secured an option on the property. They are now (November, 1899) engaged in preliminary operations to determine whether there is a sufficient amount of ore to warrant the erection of a large separating and leaching plant.* Two of the old shafts are being cleaned out and timbered and the water is to be pumped out of the lower levels of the mine. A tunnel run into the hillside at the level of the Newark meadows affords drainage for the upper 100 feet, but the lower levels—reported to be something over 300 feet deep—are full of water. From present indications it seems probable that a large amount of lean ore will be available. Narrow trap-dikes ramify through the sandstones and shale, and the rock adjoining the trap, particularly where it has been shattered and crushed so as to form a breccia, is impregnated with the copper ores—chiefly the sulphide and the carbonates. Selected lots of the ore also carry 7¼ ounces of silver per ton.* There is no true ore vein with well marked boundaries but the copper minerals occur in strings and bunches, or as finely scattered particles, or as thinly diffused coloring matter. Unless the ore is treated on the spot, a large amount of it must be thrown aside as too poor to pay the cost of transportation. Numerous analyses made of the material of the old dump-piles have led the present parties to believe that the ore, if mined on a large scale and treated economically, is rich enough to pay a good return on the investment.

---

* As this report is being printed, it has been reported that a company capitalized at $2,500,000 has secured these mines and is to operate them.

AMERICAN COPPER MINING COMPANY.

This mine is located at the base of the trap-sheet of First mountain, about three miles north of Somerville, and was formerly called the Bridgewater mine. The first opening was made during the last century, and mining has been carried on at intervals since. About 1881 work was renewed by A. H. Hovey,† and a tunnel was driven into the hillside for a distance of 228 feet, following the dip of the shales and along the base of the trap-sheet. Side-drifts to the linear extent of 240 feet were opened about that time from the main tunnel. Average samples of ore from these galleries yielded "19 per cent. of copper and 6 ounces of silver to the ton of ore."

For a few years following 1883, work was continued and the main tunnel was extended several hundred feet down the dip, but the operations as conducted were not profitable and work was abandoned. For the past two years or more, exploration has been carried on and a number of short galleries at right angles to the main tunnel have been opened at frequent intervals. All the openings are in the red shale at the base of the trap-sheet. At the time of writing (November, 1899) the work is being pushed with energy and the side galleries are being lengthened.

---

* Annual Report of the State Geologist, 1880, p. 175.

† Annual Report of the State Geologist for 1881, p. 39; and Report for 1883, p. 164.

Above ground, at the mine entrance, a steam plant and air-compressing engine furnish power to operate the drills used in the mine. A small crusher and separating plant have been put up, and tubs for leaching the ore and precipitating the copper are in operation. The work so far has been for the purpose of thoroughly developing the mine and determining beyond a doubt the extent and value of the ore deposits; but the company has in contemplation the erection of a large separating and leaching plant, capable of treating economically a large output.

The large extent of the preliminary operations has disclosed the exact mode of occurrence of the ore. The shale for a distance of from one and a half to two and a half feet from the base of the trap has been slightly altered from its normal condition. Within this altered zone the copper minerals occur. The alteration of the shale is due in part to its impregnation by the copper minerals, and in part to a slight baking, accompanied by a change in color from red to purple. The copper minerals occur in strings or bunches, or disseminated particles. They are usually more abundant near the trap, and when a well-marked pocket or sheet of ore occurs in this position, the adjoining part of the ore rock (1½ to 2½ feet in thickness) is very lean. In other places the mineral is somewhat evenly disseminated throughout the entire ore-rock. Very frequently thin films of ore occur on the faces of cracks and joints in the shale, or along bedding planes. Locally it occurs in the basal portion of the trap, particularly where the latter is somewhat broken, and is of a spongy or vesicular texture. But the thickness of the trap thus impregnated is rarely more than six to eight inches.

Owing to the method of occurrence there is considerable variation within narrow limits in the richness of the ore rock. Seams and pockets of rich ore may end suddenly and be succeeded by several feet of very lean rock. But in spite of these local and constantly recurring variations in the disposition of the ore, there is a marked uniformity in its distribution, when the whole area explored is considered. The rock along one gallery is about as rich as that along any other gallery. The openings already made render it practically certain that ore of the same grade as that already exposed will be found in the rock between each gallery. Furthermore there is no reason for thinking that the galleries may not be extended for some considerable distance beyond their present limits with the same results. That there is a much larger body of ore than is visible can hardly be doubted. On the other hand, the results already attained give no reason for believing that any marked increase in richness must necessarily be found with increasing depth. Nor in our opinion is there anything in the known or theoretical relations of the trap and shale necessitating or implying a richer ore-deposit at greater depths. This is not saying that the ore cannot become richer. It *may* or *may not* become high-grade, as it is followed down the dip.

A fault plane lies a few yards to the right (south) of the main tunnel, and the ore-bearing rock in each of the galleries on that side is lost at the fracture. The south side of the fracture has been uplifted, but there is strong evidence that the amount of dislocation is small, probably only a few feet, and that the ore-rock can readily be found again by extending the galleries a few yards to the eastward, *i. e.*, in the direction of the dip.

The ores are chiefly the red oxide and the green carbonate. Strips and sheets of metallic copper, however, are not uncommon. Small specimens of rock can be obtained giving a very high per cent. of copper. The average for the entire ore-rock is high enough to warrant the hope that, with the present high price of copper and with economical treatment, the mine will pay. The fact that it is necessary to take out almost an equal thickness of barren red shale, in order to work the ore-rock, is, however, a drawback and adds considerably to the expense.

East Jersey Water Company's Reservoir, Great Notch.

In excavating for the reservoir of the East Jersey Water Company, near Great Notch, Passaic county, a copper deposit of considerable richness was exposed. The reservoir is situated in a longitudinal valley on the back of First mountain, just west of Great Notch. As was pointed out in the Annual Report of the State Geologist for 1897, pages 121–123, this valley is located along the line of the Garrett rock-Upper Montclair fault, and owes its existence to erosion along the line of weakness produced by the fracture. In the bottom of the valley, beneath the accumulations of glacial drift, which are of considerable thickness, the red shale was found on the west side of the valley, dipping westward so as to pass beneath the ledge of trap which there bounds the depression and on the east abutting against the opposite ledge of trap along the line of fracture.

The copper ores were found along the fault in the sandstone adjoining the trap. Through the kindness of Mr. Clemens Herschel, Chief Engineer, a number of samples of the ore were furnished the Survey, and analysis showed 9.32 per cent. of metallic copper.

The trench was afterwards filled with concrete in the construction of the dam and the locality is not accessible for further investigation.

Zinc.

The attention of the Survey has again been called to the zinc ores found at Neighbor's hematite mine, one and one-half miles northeast of Califon, in Lebanon township, Hunterdon county. A brief note respecting these ores is given on pages 119 and 120 of the Annual Report for 1880. They occur in connection with limonite and iron pyrite, and are chiefly zinc sulphide and zinc carbonate, although other zinc minerals occur. A much-weathered specimen contained 8.42 per cent. of zinc and 3.10 per cent. of sulphur, and a fresh unaltered piece of ore showed 34.76 per cent. of zinc and 21.90 per cent. of sulphur. Some lead is also found associated with the zinc.

No commercial use has as yet been made of these ores, and, indeed, it is as yet impossible to say whether the ore occurs in sufficient abundance to render such use possible and profitable. In his report on the iron mines, Mr. Jenkins has a note concerning more recent operations at the mine.

Mineral Statistics

For the Year 1899.

Iron Ore.

The total production of the mines, as reported by the several mining companies, was 269,293 gross tons.

The total shipments from mines in the State, as reported by the railway companies, and reported to the office of the Geological Survey, amounted to 300,757 gross tons.

The increase in the amount of ore shipped is considerably larger than that reported in 1898.

The table of statistics is reprinted, with the total amount for 1899 added.

TABLE OF STATISTICS.

Year.	*Iron Ore.*	*Authority.*
1790,	10,000 tons,	Morse's estimate.
1830,	20,000 tons,	Gordon's Gazeteer.
1855,	100,000 tons,	Dr. Kitchell's estimate.
1860,	164,900 tons,	U. S. census.
1864,	226,000 tons,	Annual Report State Geologist.
1867,	275,067 tons,	" " "
1870,	362,636 tons,	U. S. census.
1871,	450,000 tons,	Annual Report State Geologist.
1872,	600,000 tons,	" " "
1873,	665,000 tons,	" " "
1874,	525,000 tons,	" " "
1875,	390,000 tons,	" " "
1876,	285,000 tons,*	
1877,	315 000 tons,*	
1878,	409,674 tons,	" " "
1879,	488,028 tons,	" " "
1880,	745,000 tons,	" " "
1881,	737,052 tons,	" " "
1882,	932,762 tons,	" " "
1883,	521,416 tons,	" " "
1884,	393,710 tons,	" " "

---

* From statistics collected later.

Year.	*Iron Ore.*	*Authority.*
1885, . . .	330,000 tons, . . .	Annual Report State Geologist.
1886, . . .	500,501 tons, . . .	" " "
1887, . . .	547 889 tons, . . .	" " "
1888, . . .	447,738 tons, . . .	" " "
1889, . . .	482,169 tons, . . .	" " "
1890, . . .	552,996 tons, . . .	" " "
1891, . . .	551,358 tons, . . .	" " "
1892 . . .	465,455 tons, . . .	" " "
1893 . . .	356,150 tons, . . .	" " "
1894, . . .	277 483 tons, . . .	" " "
1895, . . .	282,433 tons, . . .	" " "
1896, . . .	264,999 tons, . . .	" " "
1897, . . .	257,235 tons, . . .	" " "
1898, . . .	275,378 tons, . . .	" " "
1899, . . .	300,757 tons, . . .	" " "

Zinc Ore.

The production of the zinc mines is shown by the yearly shipments of zinc ore. The total shipments of zinc and franklinite ores, as reported by Mr. A. Heckscher, General Manager of the New Jersey Zinc Company, amounted to 154,447 gross tons in 1899.

The statistics for a period of years are reprinted from the last annual report.

ZINC ORE.

1868, . . .	25,000 tons,* . .	Annual Report State Geologist.
1871, . . .	22,000 tons, . . .	" " "
1873, . .	17,500 tons, . . .	" " "
1874, . .	13,500 tons, . . .	" " "
1878, . . .	14,467 tons, . . .	" " "
1979, . . .	21,937 tons, . . .	" " "
1880, . . .	28 311 tons, . . .	" " "
1881, . . .	49,178 tons, . . .	" " "
1882, . . .	40,138 tons, . . .	" " "
1883, . . .	56,085 tons, . . .	" " "
1884, . . .	40,094 tons, . . .	" " "
1885, . . .	38,526 tons, . . .	" " "
1886, . . .	43 877 tons, . . .	" " "
1887, . . .	50,220 tons, . . .	" " "

---

* Estimated for 1868 and 1871. Statistics for 1873-1890, inclusive, are for shipments by railway companies. The later reports are from the zinc-mining companies.

1888,	46,377 tons,	Annual Report State Geologist.
1889,	56,154 tons,	" " "
1890,	49,618 tons,	" " "
1891,	76,032 tons,	" " "
1892,	77,298 tons,	" " "
1893,	55,852 tons,	" " "
1894,	59,382 tons,	" " "
1895 *		
1896	78,080 tons,	" " "
1897,	76,973 tons,	" " "
1898,	99,419 tons,	" " "
1899,	154,447 tons	" " "

---

* No statistics were published in the Annual Report for 1895.

Publications.

The demand for the publications of the Survey is continuous and active. So far as possible requests for the reports are granted.

It is the wish of the Board of Managers to complete, as far as possible, incomplete sets of the publications of the Survey, chiefly files of the Annual Reports in public libraries, and librarians are urged to correspond with the State Geologist concerning this matter.

By the act of 1864 the Board of Managers of the Survey is a board of publication, with power to issue and distribute the publications as they may be authorized. The Annual Reports of the State Geologist are printed by order of the Legislature as a part of the legislative documents. They are distributed largely by members of the two houses. Extra copies are supplied to the Board of Managers of the Geological Survey and the State Geologist, who distribute them to libraries and public institutions, and, as far as possible, to any who may be interested in the subjects of which they treat. Several of the reports are out of print, and can no longer be supplied by the office.

The first volume of the Final Report, published in 1888, was mostly distributed during the following year, and the demand for it has been far beyond the supply. The first and second parts of the second volume and the third and fourth volumes have also been distributed to the citizens and schools of the State, and to others interested in the particular subjects of which they treat. The fourth volume includes, in an appendix, all the valuable tables which were in the first volume of this series.

The appended list makes brief mention of all the publications of the present Survey since its inception, in 1864, with a statement of editions that are now out of print. The publications of the Survey are distributed without further expense than that of transportation, excepting the maps, where a stated price covers the cost of paper and printing, as stated.

CATALOGUE OF PUBLICATIONS.

GEOLOGY OF NEW JERSEY, Newark, 1868. 8vo., xxiv + 899 pp. Out of print.

PORTFOLIO OF MAPS accompanying the same, as follows :

1. Azoic and paleozoic formations, including the iron-ore and limestone districts ; colored. Scale, 2 miles to an inch.
2. Triassic formation, including the red sandstone and trap-rocks of Central New Jersey ; colored. Scale, 2 miles to an inch.
3. Cretaceous formation, including the greensand-marl beds ; colored. Scale, 2 miles to an inch.
4. Tertiary and recent formations of Southern New Jersey ; colored. Scale, 2 miles to an inch.
5. Map of a group of iron mines in Morris county ; printed in two colors. Scale, 3 inches to 1 mile.
6. Map of the Ringwood iron mines ; printed in two colors. Scale, 8 inches to 1 mile.
7. Map of Oxford Furnace iron-ore veins ; colored. Scale, 8 inches to 1 mile.
8. Map of the zinc mines, Sussex county ; colored. Scale, 8 inches to 1 mile. A few copies are undistributed.

REPORT ON THE CLAY DEPOSITS of Woodbridge South Amboy and other places in New Jersey, together with their uses for fire-brick, pottery, &c. Trenton, 1878, 8vo., viii + 381 pp., with map.

A PRELIMINARY CATALOGUE of the Flora of New Jersey, compiled by N. L. Britton, Ph.D. New Brunswick, 1881, 8vo., xi + 233 pages. Out of print.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. I. Topography. Magnetism. Climate. Trenton, 1888, 8vo., xi + 439 pp. Very scarce.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part I. Mineralogy. Botany. Trenton, 1889, 8 vo.. x + 642 pp.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part II. Zoology. Trenton, 1890, 8vo., x + 824 pp.

REPORT ON WATER SUPPLY. Vol. III of the Final Report of the State Geologist. Trenton, 1894, 8vo , xvi + 352 and 96 pp.

REPORT ON THE PHYSICAL GEOGRAPHY of New Jersey. Vol IV of Final Report of the State Geologist. Trenton, 1898, 8vo., xvi+170+200 pp

BRACHIOPODA AND LAMELLIRANCHIATA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1886, quarto, pp 338, plates XXXV and Map. (Paleontology, Vol. 1.)

GASTEROPODA AND CEPHALOPODA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1892, quarto, pp. 402, plates L. (Paleontology, Vol. II.)

Atlas of New Jersey. The complete work is made up of twenty sheets, each 27 by 37 inches, including margin, intended to fold once across, making the leaves of the Atlas 18½ by 27 inches. The location and number of each map are given below. Those from 1 to 17 are on the scale of one mile to an inch.

No. 1. *Kittatinny Valley and Mountain*, from Hope to the State line.
No. 2. *Southwestern Highlands*, with the southwest part of Kittatinny valley.
No. 3. *Central Highlands*, including all of Morris county west of Boonton, and Sussex south and east of Newton.
No. 4. *Northeastern Highlands*, including the country lying between Deckertown, Dover, Paterson and Suffern.
No. 5. *Vicinity of Flemington*, from Somerville and Princeton westward to the Delaware.
No. 6. *The Valley of the Passaic*, with the country eastward to Newark and southward to the Raritan river.
No. 7. *The Counties of Bergen, Hudson and Essex*, with parts of Passaic and Union.
No. 8. *Vicinity of Trenton*, from New Brunswick to Bordentown.
No. 9 *Monmouth Shore*, with the interior from Metuchen to Lakewood.
No. 10. *Vicinity of Salem*, from Swedesboro and Bridgeton westward to the Delaware.
No. 11. *Vicinity of Camden*, to Burlington, Winslow, Elmer, and Swedesboro.
No. 12. *Vicinity of Mount Holly*, from Bordentown southward to Winslow and Woodmansie.
No. 13. *Vicinity of Barnegat Bay*, with the greater part of Ocean county
No 14. *Vicinity of Bridgeton*, from Allowaystown and Vineland southward to the Delaware bay shore.
No. 15. *Southern Interior*, the country lying between Atco, Millville and Egg Harbor City.
No. 16. *Egg Harbor and Vicinity*, including the Atlantic shore from Barnegat to Great Egg Harbor.
No. 17. *Cape May*, with the country westward to Maurice river.
No. 18. *New Jersey State Map*. Scale, 5 miles to an inch. Geographic.
No. 19. *New Jersey Relief Map*. Scale, 5 miles to the inch. Hypsometric.
No. 20. *New Jersey Geological Map*. Scale, 5 miles to the inch.

The maps comprising The Atlas of New Jersey are sold at the cost of paper and printing, for the uniform price of 25 cents per sheet, either singly or in lots. Payment, invariably in advance.

TOPOGRAPHIC MAPS, NEW SERIES.

The economic topographic maps of the Survey, on a scale of one inch to 2,000 feet, are sold at 25 cents per sheet. The following sheets are ready: JERSEY CITY, NEWARK, HACKENSACK, PATERSON and CAMDEN. They may be had by addressing the State Geologist, Trenton, N. J., with remittance for amount of order.

ANNUAL REPORTS.

REPORT OF PROFESSOR GEORGE H. COOK upon the Geological Survey of New Jersey and its progress during the year 1863. Trenton, 1864. 8vo., 13 pp. Out of print.

THE ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to His Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1864. Trenton, 1865, 8vo., 24 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to his Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1865. Trenton, 1866, 8vo., 12 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, on the Geological Survey for the year 1866. Trenton, 1867, 8vo., 28 pp. Out of print.

REPORT OF THE STATE GEOLOGIST, Prof. Geo. H Cook, for the year 1867. Trenton, 1868, 8vo , 28 pp. **Out of print.**

ANNUAL REPORT of the State Geologist of New Jersey for **1869. Trenton**, 1870, 8vo., 57 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for **1870. New** Brunswick, 1871, 8vo., 75 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1871. **New** Brunswick, 1872, 8vo., 46 pp., with maps. **Out of print.**

ANNUAL REPORT of the State Geologist of New Jersey for **1872. Trenton**, 1872 8vo., 44 pp., with map. **Out of print.**

ANNUAL REPORT of the State Geologist of New Jersey for 1873. **Trenton**, 1874, 8vo., 128 pp., with maps. **Out of print.**

ANNUAL REPORT of the State Geologist of New Jersey for **1874. Trenton**, 1874, 8vo , 115 pp. **Out of print.**

ANNUAL REPORT of the State Geologist of New Jersey for 1875. **Trenton**, 1875, 8vo., 41 pp , with map **Out of print.**

ANNUAL REPORT of the State Geologist of New Jersey for 1876. **Trenton**, 1876, 8vo., 56 pp., with maps. **Out of print.**

ANNUAL REPORT of the State Geologist of New Jersey for 1877. **Trenton**, 1877, 8vo , 55 pp. **Out of print**

ANNUAL REPORT of the State Geologist of New Jersey for 1878. **Trenton**, 1878, 8vo., 131 pp., with map. **Out of print.**

ANNUAL REPORT of the State Geologist of New Jersey for 1879. **Trenton**, 1879, 8vo., 199 pp., with maps. **Out of print.**

ANNUAL REPORT of the State Geologist of New Jersey for 1880. Trenton, 1880, 8vo., 220 pp. with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1881. Trenton, 1881, 8vo., 87 + 107 + xiv pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1882. Camden, 1882, 8vo., 191 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1883. Camden, 1883, 8vo , 188 pp. Scarce.

ANNUAL PEPORT of the State Geologist of New Jersey for 1884. Trenton, 1884, 8vo , 168 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1885. Trenton, 1885, 8vo., 228 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1886. Trenton, 1887, 8vo., 254 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1887. Trenton, 1887, 8vo., 45 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1888. Camden, 1889, 8vo. 87 pp., with map.

ANNUAL REPORT of the State Geologist of New Jersey for 1889. Camden, 1889, 8vo., 112 pp.

ANNUAL REPORT of the State Geologist of New Jersey for 1890. Trenton, 1891, 8vo , 305 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1891. Trenton, 1892, 8vo., xii + 270 pp., with maps. Scarce.

ANNUAL REPORT of the State Geologist of New Jersey for 1892. Trenton, 1893 8vo., x + 368 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1893. Trenton, 1894, 8vo., x + 452 pp., with maps.

ANNUAL REPORT of the State Geologist of New Jersey for 1894. Trenton, 1895, 8vo., x + 304 pp., with geological map.

ANNUAL REPORT of the State Geologist of New Jersey for 1895. Trenton, 1896, 8vo , xl + 198 pp., with geological map.

ANNUAL REPORT of the State Geologist of New Jersey for 1896. Trenton, 1897, 8vo., xxviii + 377 pp , with maps of Hackensack meadows.

ANNUAL REPORT of the State Geologist of New Jersey for 1897. Trenton, 1898, 8vo., xl + 368 pp.

ANNUAL REPORT of the State Geologist for 1898. Trenton, 1899, 8vo., xxxii + 244 pp., with Appendix, 102 pp.

ANNUAL REPORT of the State Geologist for 1899 and REPORT ON FORESTRY. Trenton, 1900 8vo., Annual Report, xliii + 190 pp.

INDEX.

INDEX.

A.

Page

Absecon Wells 121

Allen Mine 162

American Copper Mining Company 172

Analyses of Iron Ores 165

Analyses of Waters 145

Arlington, Copper Mine at 171

Artesian Wells, Report on 55

Artesian Well Waters, Analyses of 147

Asbury Park, Analyses of Artesian Well Waters of 147

Asbury Park, West, Artesian Wells at 74

Atlantic City, Analyses of Waters of Artesian Wells 147

Atlantic City, Artesian Wells at 106, 124

Atrypa Reticularis in Decker Ferry Formation 11

B.

Babylon, L. I., N. Y., Artesian Well 79

Barrett, Dr. S. T , Reference to 19

Beach Glen Mines 155

Becraft Limestone 39

Beecher and Clarke, Reference to 40

Bernardsville, Artesian Wells at 127

Black Hills Mine 161

Bossardville Limestone 6

Bossardville Limestone for Lime 24

Bowers Beach, Del., Artesian Well at 110

Brick House, Red Limestone at 13

Bridgeton, Artesian Well at 102

Bridgewater Copper Mine 172

Brotherton Mine 161

Burlington, Bored Wells at 71

C.

Cambrian Trilobites 47

Camden, Artesian Well in 66

Carpentersville, Fossils in Limestone 48

Catskill Shaly Limestone. See "New Scotland Beds."

Cauda-Galli Grit. See "Esopus Grit."

Cedarville, Artesian Well at 103

Cement Rock of Rondout Water-lime Formation 20

Centreville, Md., Artesian Well at 81

Chamberlin, T. C., References to Papers of, 23, 27

Chert in Onondaga Limestone 45

Chesapeake Beach, Md., Artesian Well at 83

Page

Chester, Prof. A. H., Care of Mineralogical Collections xxxiii

Chlorine in Natural Waters 141

Chonetes Jerseyensis 8, 13

Choctetes Lycoperdon, Monotrypa Undulata, 11

Clark, Prof. Wm. B., Reference to 83

Clark and Schuchert, Reference to...7, 18, 20, 25, 28

Clove Brook, Valley of 4

Coeymans Limestone 28

Colestown, Artesian Well near 68

Columbus, Artesian Well at 72

Conlan, P. H. & J., Records of Wells Bored.. 125, 134-139

Continental Borders in Silurian Time 23

Cook, Prof., "Ribbon Limestone" of 6, 19

Cook, Prof., "Pethstone" of 20

Copper Mines, Notes on 171

Coralline Limestone of New York 19

Cretaceous Formations, Bored Wells in 60-102

D.

Dalrymple Mine 160

Darton, N. H., References to 86, 88, 98, 113

Decker Ferry Formation 7

Decker Ferry Formation, Correlation of Faunas of 17

Decker Ferry Formation, Fossils in 8

DeKay Farm, Opening 162

Delaware River, Analyses of Water of 145, 146

Delaware Water Gap, Bossardville Limestone at 24

Delmar, Del., Artesian Well at 111

Devonian System, Formations of 24

Drainage, Passaic Wet Meadows xxiv

E.

East Burlington, Boring at 71

East Jersey Water Co.'s Reservoir, Copper at 174

Easton, Pa., Artesian Well at 133

Elizabeth, Bored Well at 130

Erb and Scrub Oaks Mine 161

Esopus Grit 44

F.

Fellows Mine 159

Flatbrook, Valley of 4

Flatbrookville, Decker Ferry Formation at..7, 8, 11

Flatbrookville, Limestone for Lime 24

Flatbrookville, Coeymans Limestone at 30

Page
Flatbrookville, New Scotland Beds at 36
Flatbrookville, Stormville Sandstone at 39
Flatbrookville, Esopus Grit at 44
Flatbrookville, Onondaga Limestone at 46
Flemington, Bored Wells at 128
Foerste A, Reference to 48
Ford Mine 159
Forest Fires, Legislation xxviii
Forest Surveys xxv
Formations, Marine and Non-Marine 22
Formations, Paleozoic, Report on 1

G.

Geological Rooms xxxiii
Great Notch Reservoir, Copper Ore at 174
Greenbank, Artesian Well at 104
Green Pond Mine 157
Grit, Esopus 44
Gypidula Galeata Zone 28

H.

Hackensack Meadows, Reclamation of xxxix
Hainesville, Fossil Species in Limestone at 10
Hainesville, Coeymans Limestone at 31
Hainesville, New Scotland Beds at 34, 36
Hancock's Bridge, Artesian Well at 61
Harrison Artesian Well 136
Hardistonville Quartzite 47
Helderbergian Formations, Position of 25
Hematite Iron Ores 163
Hibernia Mines 156
High Ledge Mine 162
Hoff Mine 162
Hunterdon County, Well Borings in 128
Huntsville, Bored Well at 127
Hurdtown, Mine at 152

I.

Iron Mining Industry, Report on 151
Iron Ores, Analyses of 165
Iron Ore, Statistics of 177

J.

Jenkins, George E., Report of 151
Jersey City, Artesian Wells in 138, 139

K.

Kearney, Artesian Well at 136
Kennedyville, Md, Artesian Well at 81
Kishpaugh Mine 159
Kittatinny Valley, Paleozoic Rocks in 4
Kümmel, H. B., Notes on Copper Mines by 171

L.

Lambert's Point, Va., Artesian Well at 87
Lakewood, Artesian Wells at 73
Lakewood Artesian Well Waters, Analyses of 147

Page
Laurel, Del., Artesian Well at 125
Laurel Springs, Artesian Wells at 64
Limestone, Becraft 39
Limestone, Bossardville 6
Limestone, Coeymans 28
Limestone, Manlius 24
Limestone, Onondaga 45
Limestone, Red, at Brick House 13
Limestone for Lime 24
Linden, Bored Well at 130
Liostracus Jerseyensis 51
Little Silver, Artesian Well at 79
Long Island, Artesian Wells on 79, 125
Long Island, Wells Bored on 132
Lower Pentamerus Limestone 26

M.

Madison, Md., Artesian Well at 111
Magnetic Iron Ore Mines 151
Magnesian Limestone, Fossils in 48
Mahon River, Del, Artesian Well at 110
Managers, Board of vii
Manlius Limestone 6, 19, 24
Maps, Geological xii
Maps, Topographic xxii, 183
Marlton, Artesian Wells at 69
Matthews Brothers, Records of Wells by 77
Maywood, Bored Wells at 129
Meadows, Reclamation of xxxix
Medina Sandstone of Kittatinny Mountain 4
Mickleton, Artesian Well near 63
Milford, Artesian Well at 70
Mineral Statistics 177
Mineralogical Collections xxxiii
Mines, Iron, Report on 152
Mines, Zinc 163
Mining Industry 149
Miocene Formations, Artesian Wells in 102
Mount Hope Mines 154
Museum, Geological xxxiii
Myers, Wm. S., Report of 141

N.

Nearpass Section of Paleozoic Rocks 5
Nearpass Section, Decker Ferry Limestone in, 8
Nearpass Section, *Gypidula Galeata* Zone at, 28
Nearpass Section, Becraft Limestone at 40
Nearpass Section, Oriskany Beds at 42
Neighbor Mine, Zinc Ore at 163, 175
Newark, Artesian Wells in 135
Newark Meadows, Reclamation of xxxix
New Scotland Beds 32
New Scotland Beds, Fossils in 38
New Sterling and Hurd Mines 156
New York City Artesian Well, 72d Street 139
Niagara Formation, Equivalency with Decker Ferry Formation 18
Nickel in Magnetic Iron Ore 166
Norfolk, Va., Artesian Wells at 87, 92, 93
Northfield Well 130

O.

Page

Ocean City, Artesian Well at 108
Olenellus, Trilobites 47
Onondaga Limestone 45
Orchard Mine 161
Ore, Copper, Mines, Notes on 171
Ores, Iron, Analyses of 165
Ores, Iron, Report on 151
Ore, Iron, Statistics of 177
Ore, Zinc, Statistics of 178
Oriskany Formation 42
Ostracodes in Manlius Limestone 24
Ostracodes in Rondout Water-Lime Formation 21
Oxford Mines 159

P.

Paleozoic Formations, Report on 1
Passaic, Bored Wells in 131, 137
Passaic River Valley, Drainage of xxiv
Passaic River Valley, Test Borings in 136
Passaic River Water, Analyses of 145, 146
Pedricktown, Artesian Well Near 63
"Pethstone" of Prof. Cook 20
Pennsville, Wells at 61
Pensauken, Artesian Well Near 67
Pentamerus Limestone 28
Perkintown Station, Artesian Wells Near 62
Peter's Valley, Decker Ferry Formation at .. 7, 14
Peter's Valley, Coeymans Limestone at 29
Peter's Valley, New Scotland Beds at 36
Peter's Valley, Becraft Limestone at 41
Peter's Valley, Oriskany Formation at 43
Peter's Valley, Onondaga Limestone at 45
Philadelphia, Test Borings at Navy Yard 117
Pocomoke City, Md, Artesian Wells at 116
Pompton, Well-Boring at 138
Port Monmouth, Artesian Well at 78
Poxino Island Shale 5, 20
Poxino Island Shale, Correlation of 20
Ptilodictya Platyphylla Zone of Decker Ferry Formation 12
Publications .... xxxv, 181

Q.

Queen Mine 159
Quarry, Nearpass Section 5
Quarry Limestone, Walpack Ridge 24

R.

Rahway, Test Boring at 138
Raritau River, Analyses of Water of 146
Reports, List of 182
Rhynconella' Lamellata Zone of Decker Ferry Formation 14
"Ribbon Limestone," of Cook 6, 19
Richard Mines 152
Ringwood Mines 160
River Water, Analyses of 146

Page

Riverton, Artesian Well near 70
Rondout, N. Y., "Ribbon Limestone" at 6
Rondout Water-Lime Formation 20
Rumson Bluff, Artesian Well at 78

S.

Salisbury, Md., Artesian Well at 112
Salisbury, Prof. R. D., Report of .... xi, xxxvii
Sandstone, Stormville 39
Schuyler Mine 171
Scrub Oaks or Dell Mine 161
Seabright, Artesian Wells at 76
Seaford, Del., Artesian Wells at 126
Ses Isle City, Artesian Well at 109
Seas, Land-locked, and their Sediments 23
Sediments, non-marine 22
Severn River, Va., Artesian Well 86
Shale, Poxino Island 5
Shannahan, J. H. K., Reports of Wells, 81, 116, 125
Shooter's Island, Boring on 138
Silurian System, Formations of 5
Silurian and Devonian Systems, Division between 25
Silurian Time, Seas of 22
Smithville, Artesian Well at 72
Smith's Landing, Artesian Well at 104
Somerset County, Bored Wells in 127–130
Somerville, Bored Wells at 129
Somerville, Copper Mine near 172
Spirifer Macropleurus 35
Spirifer Perlamellosus 33
Spirifer Vanuxemi Zone 24
Springs, Analyses of Waters of 145
Staten Island, N. Y., Bored Wells on 132
Statistics, Mineral 177
Stormville Sandstone 39
Stotthoff Brothers, Wells Reported by 126
Summit, Artesian Wells near 134
Sussex County, Walpack Ridge, Report on... 3
Sussex County, Wells Bored in 127

T.

Taylor's Island, Md., Artesian Well 85
Tentaculite or Manlius Limestone 6
Terebratula Harlani, Well Borings in 86
Tilghman's Island, Md., Artesian Well at 84
Time-divisions, Geologic 23, 25
Topographic Maps 183
Trenton, Bored Well in 130
Trilobites, Cambrian 47
Trilobite Ridge, N. Y 40

V.

Vermeule, C. C., Report on Reclamation of Hackensack and Newark Meadows xxxix

W.

Page
Walcott, Director Chas. D., Reference to Reports of.... 51
Walpack Bend.... 4
Walpack Bend, " Pethstone " at.... 21
Walpack Ridge, Quarry Stone of.... 24
Walpack Ridge, Stratigraphic Paleontology... 3
Walpack Valley.... 4
Water-lime Formation.... 20
Water-lime Formation, Non-marine life of....22, 27
Waters, Natural, Chlorine in.... 141
Weller, Stuart, Report of.... 1
Weller, Stuart, Descriptions of Cambrian Trilobites.... 47
Wells, Artesian, Analyses of Waters of.... 147
Wells, Artesian, Report on.... 55
West Orange Artesian Well.... 136
Westville, Artesian Well at.... 65

Page
Wharton Mine, Hibernia.... 157
White, Prof. I. C., References to Reports of 6, 33, 44
White, Uriah, Wells Bored by.... 104, 107, 108, 109, 121
Wolff and Brooks, Reference to Reports of.... 47
Woodside, N. Y., Artesian Well at.... 80
Woolman, Lewis, Report of.... 55

Y.

Yardley, Pa , Bored Wells at.... 134

Z.

Zinc Mines.... 163
Zinc Ore, Statistics of.... 178

GEOLOGICAL SURVEY OF NEW JERSEY

ANNUAL REPORT

—OF—

THE STATE GEOLOGIST

For the Year 1899

REPORT

—ON—

FORESTS

TRENTON, N. J.:
MacCrellish & Quigley, State Printers, Opposite Post Office.
1900.

BOARD OF MANAGERS.

His Excellency FOSTER M. VOORHEES, Governor, and ex officio President of the Board,	Trenton.

I. Congressional District.

EDWARD C. STOKES,	Millville.
CLEMENT H. SINNICKSON,	Salem.

II. Congressional District.

EMMOR ROBERTS,	Moorestown.
WASHINGTON A. ROEBLING,	Trenton.

III. Congressional District.

HENRY S. LITTLE,	Matawan.
M. D. VALENTINE,	Woodbridge.

IV. Congressional District.

FREDERICK A. CANFIELD,	Dover.
GEORGE RICHARDS,	Dover.

V. Congressional District.

GEORGE W. WHEELER,	Hackensack.
WILLIAM F. HALL,	Pompton Lakes.

VI. Congressional District.

THOMAS T. KINNEY,	Newark.
FREDERIC W. STEVENS,	Newark.

VII. Congressional District.

LEBBEUS B. WARD,	Jersey City.
SAMUEL B. DOD,	Hoboken.

VIII. Congressional District.

ERNEST A. ACKERMAN,	Plainfield.
WENDELL P. GARRISON,	Orange.

PREFACE.

The forests of the State have been considered as coming within the limits of the investigations and surveys of the Geological Survey, and the determination of the extent of the forested land and the mapping of these lands have been included in the work of the Topographic Division. Early in the history of the Topographic Survey the mapping of the forest area was made to take note of the pine lands, the cedar-swamp lands and the mixed pine and deciduous forest. Some attention was given to the condition of the timber and to its protection against forest fires, and in the Annual Report of the State Geologist for 1885 there was a section on Forestry and Forest Fires. On the completion of the topographic survey of the State in 1887 the publication of the Atlas of Topographic Maps gave practically sectional forest maps, which showed the location, extent and topographic situation of all the forested lands in the State. In the Report on Topography, published in 1888, and entitled "Final Report of the State Geologist, Vol. I, Topography, Magnetism and Climate," there were many notes on the extent and nature of the forests, and their relation to the characteristic soils of the great natural divisions of the State. In the Annual Report of the State Geologist for 1891 the oak-land and pine-land belts of Southern New Jersey were described by C. W. Coman, Assistant Geologist to the Survey. The studies of Mr. C. C. Vermeule, Topographer of the Survey, on Water-Supply and Water-Power, which were begun in 1890, also covered the subject of forests and their relation to water-supply. His annual reports for 1890, 1891, 1892 and 1893 and the full report in 1894 had many references to the forested conditions of the several water-sheds.

The first specific enactment of the Legislature directing a survey of the forested lands of the Sate was made in the session of 1894. It provided for a survey, to be made under the direction of the Board of Managers of the Geological Survey, by the State Geologist, assisted by a competent botanist and expert in forestry. The leading objects of this survey of the wooded lands of the State were to ascertain their extent, character and location and "the advantages as regards timber-supply, water-supply, scenery and climate of the State, which would accrue from the conservation of existing forests" by the establishment of a State forest reservation, and the preparation of a report which should give "an outline of the policy and legislation of other States and countries for the preservation of forests and their regulation for public ends so far as the same may be applicable to this State." The field work was begun in the summer of 1894, and in the Annual Report of the Survey for that year there were two papers; one by Mr. Vermeule, "On Forestry in the Northern Part of the State," and one by John Gifford, entitled "A Preliminary Report on the Forest Conditions of South Jersey." In 1895 the reports were entitled: "Report on Forestry in Northern New Jersey," by C. C. Vermeule; "Report on Forest Fires for Season of 1895," by John Gifford, and "Notes on the Forests of New Jersey," by Gifford Pinchot. In 1896 Mr. Gifford had a report: "Notes Collected During a Visit to the Forests of Holland, Germany, Switzerland and France." In 1897 Mr. Gifford Pinchot, who had been appointed botanist to the Survey (now Chief of the Division of Forestry, U. S. Department of Agriculture), surveyed the southern part of the State, and his report, entitled "A Study of Forest Fires and Wood Production in Southern New Jersey," was published as an appendix to the last Annual Report of the State Geologist. Mr. Vermeule prepared a paper on "The Pine Belt of Southern New Jersey and Water-Supply," for the same annual. Professor Arthur Hollick, of Columbia University, New York, was engaged in 1896 and 1897 to study the distribution of the tree species in the State and their relation to the geological formations. A summary of the results of his studies was incorporated in the administrative report for 1898.

The general report made at this time has four principal divisions or parts. Part I, by C. C. Vermeule, gives a general description of the forested area and the conditions of the timber in the several natural divisions of the State. In his notes on the forests of Southern New Jersey, Mr. Vermeule has made use of the report of Mr. Pinchot. The sections on "The Effects of Fire," "The Plains," and "Silvicultural Notes on the White Cedar," are by Mr. Pinchot. Two important sections at the end of this Part, on "Forests and Water-Supply" and "Forests and Climate," contain the conclusions of Mr. Vermeule's years of study of the great question of water-supply and its relations.

Part II, "The Relation Between Forestry and Geology in New Jersey," is by Prof. Arthur Hollick. It contains many facts about the distribution of the more common trees of the State and discusses their relation to the geological formations and the evolution of the tree species. Professor Hollick divides the State into a zone of deciduous or broad-leaved trees, a Coniferous Zone, and an intermediate one which he terms "The Tension Zone."

Part III, "The Role of Insects in the Forest," is contributed by Professor John B. Smith, of New Brunswick, and State Entomologist.

Part IV, "The Forestal Conditions and Silvicultural Prospects of the Coastal Plain of New Jersey," is by Dr. John Gifford, Professor in the New York State College of Forestry at Cornell University. His report has many notes on the conditions of the forests in the southern part of the State, and many suggestions about industries which may help the land-owner, and practical recommendations for protection against fires, as drawn from his observations of the Belgian Campine, in the Landes of France and the heath-lands of Northern Germany.

The Introduction is by the State Geologist.

The meteorological statistics in the section on "Forests and Climate," in Part I, were furnished by E. W. McGann, Section Director of the New Jersey Weather Bureau, for the New Jersey stations. The results of the studies of these official records of temperature and rain-fall are condensed in graphic form in the State maps, Plates XI, XII and XIII. After Mr. Vermeule's investigation and careful study of these records in relation to forested areas, the plan of this report, including a part on "Forests and Climate," was changed, and the paper was omitted.

The illustrations in the volume are in part from photographs taken by Mr. Pinchot and used in his report in 1898, and photographs from Mr. Gifford of European forest scenes and scenery.

The maps consist of a State map on the scale of five miles to an inch, showing the forest density by shaded areas, and the large six-sheet map of "The Forests of Northern New Jersey," based on the topographic maps and on a scale of one mile to an inch. The maps were prepared under the immediate supervision and direction of the topographer, C. C. Vermeule. The printing was done by Messrs. Julius Bien & Co., engravers and printers of the topographic maps of the Geological Survey.

The ample opportunities given by the printers, Messrs MacCrellish & Quigley, for careful revision of proofs and their interest in the mechanical execution of the work deserve record in this place.

This Report is necessarily incomplete, and at the end of the work in its preparation it is as if we were at the beginning of our studies of forestry, so wide is the range of inquiry and so far afield do the associated groups of related studies lead us. Cognizant of its imperfections, it is sent out to give information as to our needs of a scientific treatment of our forests and a State policy of protection and to stimulate a growing sentiment about forestry into an active practice of silviculture. It is hoped that it may appeal to all lovers of trees and of our woodlands as well as to the large landholders, and that its suggestions may take form in natural parks in the vicinity of our cities, in forest and game preserves in our Highlands and Kittatinny mountains and in the Pines of Southern New Jersey, and in timbered lands throughout all the State where wood shall be a valuable crop, and all protected and fostered by an intelligent public sentiment.

JOHN C. SMOCK,
State Geologist.

TRENTON, N. J.

Law Authorizing this Survey and Report.

[Laws of New Jersey—Session 1894, Chapter CXX.]

1. Be it enacted *by the Senate and General Assembly of the State of New Jersey,* That the state geologist, under the direction of the board of managers of the geological survey, and with the assistance of a competent botanist to be selected by said board for his expert knowledge of forestry and of the forest trees of this state, and such other expert assistance as may be required for the purpose, shall make an investigation to ascertain the extent, character and location of the wild lands in this state which are suited for permanent occupation by forests rather than by agriculture, and shall report the results of such investigation to the legislature, together with a statement of what part or parts of such lands would be suitable for a state forest reserve, and the advantages as regards the timber-supply, water-supply, scenery and climate of the state, which would accrue from the conservation of existing forests by the establishment of such reserve or otherwise; the investigation so to be made shall determine the extent to which forests of timber of commercial value now exist in the state, and include a study of the localities and areas which are specially adapted to the growth of designated kinds of timber of commercial value; it shall also include an examination as to the presence or absence of forest cover upon the slopes and summits of the more important water-sheds of the state, and a study of the effect of such conditions as now exist upon the maintenance of the streams therein and the regulation of the freshet-flow thereof; the report to the legislature shall state the arguments touching the beneficial effect, upon climate and rainfall attributable to the presence of forests, and shall likewise present an outline of the policy and legislation of other states and countries for the preservation of forests and their regulation for public ends, so far as the same may be applicable to this state.

2. *And be it enacted,* That the expense of making such investigation and report, shall, when duly audited by the board of managers and approved by the governor and comptroller, be paid out of the funds in the treasury not otherwise appropriated, and shall be limited to five thousand dollars.

3. *And be it enacted,* That this act shall take effect immediately.

Approved May 1, 1894.

CONTENTS.

PAGES.

Introduction, ... 1-12

Part I.

The Forests of New Jersey. By C. C. Vermeule.

Physical Condition of Forests of New Jersey, ... 13-43
  Distribution of Forests, ... 15-16
  Area of Forest by Counties, ... 16-18
  Changes in Forest Area, ... 18-19
  Changes in Physical Condition, ... 19-23
  Value of Forest Product, ... 23-25
  Value of Standing Timber, ... 25-28
  Range in Sizes of Standing Timber, ... 28-29
  Large Trees, ... 29-32
  Relative Productiveness of Topographic Divisions, ... 32-34
  Growth of Trees, ... 34-37
  Influence of Moisture, ... 37-39
  Forest Fires, ... 39-41
  Forest Management, ... 41-43
Field Notes of Forest Conditions, ... 45-101
  Introduction and Classification, ... 45-46
  Northeastern Highlands, ... 46-67
  Southwestern Highlands, ... 67-76
  Passaic Valley, ... 76-80
  Watchung Mountains, ... 80-83
  Hackensack Valley, ... 83-87
  Palisades Mountain, ... 87-88
  Remainder of Glaciated Red Sandstone, ... 88-89
  Unglaciated Red Sandstone, ... 89-95
  Pines Belt—Northwest Border, ... 95-100
  Fires in the Pine Forest, ... 100-101
The Effects of Fire. By GIFFORD PINCHOT, ... 103-108
  Damage to Standing Trees, ... 103-104
  Effect on Cedar Swamps, ... 104
  Injury to Young Growth, ... 104
  Injury to the Soil, ... 104
  Moral Effect of Fires on Population, ... 107-108

PAGES.

- Effect of Fire on Forest Production. By GIFFORD PINCHOT, 109-123
  - The Original Timber, 109-110
  - Second Growth, 110
  - Conclusions from Valuation Surveys, 110-112
  - Descriptions of Representative Areas, 113
    - Original Forest at Winslow, 113-115
    - Original Forest at New Lisbon, 115-116
    - Second Growth at Whitings, 117-119
    - Pine Sprouts at Whitings, 119-120
    - Second Growth After Fire, 120-123
- The Plains. By GIFFORD PINCHOT, 125-130
  - Age of the Pine, 126-128
  - Cause of Present Condition, 129-130
- Silvicultural Notes on the White Cedar. By GIFFORD PINCHOT, 131-135
  - Situation, 131-132
  - Reproduction, 132
  - Growth, 132-134
  - Yield, 134-135
- Forests and Water-Supply, 137-166
  - General Statement, 137-138
  - Effect of Forests upon Evaporation, 139-152
  - Effect upon Maximum and Minimum Flow of Streams, 152-165
  - Effect on the Purity of the Water, 165-166
- Forests and Climate, 167-172

Part II.

The Relation Between Forestry and Geology. By Arthur Hollick.

- Letter of Transmittal, 175
- I. Existing Conditions, 177-193
    - Object and Scope of Report, 173-179
    - Method of Investigation Pursued, 180-181
    - Facts Ascertained, 181-190
    - Discussion of the Facts, 190-193
- II. Historical Development, 193-201
    - Preliminary Discussion, 193-194
    - Mesozoic Time, 194-199
      - Triassic Period, 194
      - Jurassic Period, 195
      - Cretaceous Period, 195-197
    - Neozoic Time, 197-199
      - Tertiary Period, 197-198
      - Quaternary Period, 198-199
  - Concluding Remarks, 199-201

Part III.

The Role of Insects in the Forest. By John B. Smith.

PAGES.
Introduction, ... 205
Foliage-Destroying Insects, ... 205-208
Galls on Trees, ... 208-210
Scale Insects, ... 210-211
Borers, ... 211-222
Insects in Dead Wood, ... 222-228
Care of Forests and Protection Against Insects, ... 228-232

Part IV.

Forestal Conditions and Silvicultural Prospects of the Coastal Plain of New Jersey. By John Gifford.

I. General Description, ... 235-263
  Boundaries—Life-Zones—Soil, ... 235-238
  The Plains, ... 238-241
  The Pine Barrens, ... 241-244
  The Swamp Lands, ... 244-248
  The Salt Marshes, ... 248-250
  The Coastal Dunes, ... 250-252
  Historical Notes, ... 252-257
  Forest Industries, ... 257-263
II. Forest Policy and Silvicultural Suggestions, ... 265-292
  Forest Policy, ... 265-276
  Silvicultural Suggestions, ... 276-292
III. Parts of Europe Similar to Southern New Jersey, ... 293-318
  General Statement, ... 293-295
  The Belgian Campine, ... 296-302
  The Dunes and Landes of Gascony, ... 302-309
  The Banat Sand-Desert of Southern Hungary, . . 309-311
  The Lüneburg and Other Adjacent Heath and Moor Lands, 311-316
  Forestry in Denmark, ... 316-318
Index, ... 321-327

ILLUSTRATIONS.

Maps.

Map of Forests of Northern New Jersey (in six sheets), ... In tube.
Map of New Jersey, showing the Density of Forest, ... In tube.

Plates.

Facing Page
Plate I.—New Jersey ; Showing Geological Formations, ... 13
Plate II.—Diagram showing Rate of Growth of Short-leaf Pine and of Deciduous Trees, ... 34
Plate III.—New Jersey ; Showing Percentage of Forest Cover and Limits of Deciduous and Coniferous Forest, ... 95
Plate IV.—Pitch Pine sprouting in the crown, after a fire which killed all the leaves, Ocean county, ... 104
Plate V.—Original Pine Forest at New Lisbon, ... 110
Plate VI.—Second Growth Pitch Pine, Ocean county, ... 115
Plate VII.—Badly Burned Pine, with Stunted Oak Sprouts underneath, Burlington county, ... 119
Plate VIII.—Repeatedly Burned Land, with Sprouts of Oak and Pine, Tuckerton, ... 123
Plate IX.—General View of the East Plains, ... 125
Plate X.—Curve Showing Average Growth of White Cedar, . . 131
Plate XI.—New Jersey ; Showing Mean Annual Rain-fall and Mean Temperature, ... 167
Plate XII.—New Jersey ; Showing Mean Rainfall for Growing Months, and Mean Summer Temperature, ... 167
Plate XIII.—New Jersey ; Showing Mean Rain-fall for Months of No Growth, and Mean Winter Temperature, ... 167
Plate XIV.—Secular Changes in Annual Rain-fall, ... 170
Plate XV.—The Tulip Soft Scale, *Lecanium Tulipifera*, ... 210
Plate XVI.—Burrows made by the Hickory Bark-beetle. This is a section of bark from a tree about 15 inches in diameter, killed by these insects, ... 212
Plate XVII.—Entrance to the Pheasantry of Compeigne, France, . 233
Plate XVIII.—The Plains of South Jersey, ... 238
Plate XIX.—The Pines at Lakewood, ... 242
Plate XX.—A White-Cedar Swamp, *Magnolia Glauca*, ... 246
Plate XXI.—The Crest of the Sand Dune on Seven-Mile Beach, . . 250
Plate XXII.—Hollies on Seven-Mile Beach, ... 251
Plate XXIII.—A Group of Red Cedars on the Coast of New Jersey, 252

Facing Page
Plate XXIV.—Binding Twigs into Faggots; Sawing Boards by Hand in France, ... 288
Plate XXV.—An Avenue on the Dutch Dunes, ... 294
Plate XXVI.—Natives of the Landes; a Church which was Buried by the Sand on the French Dunes, ... 303
Plate XXVII.—A Forest on the French Dunes, near Arcachon, . . . 304
Plate XXVIII.—Arcachon, ... 308
Plate XXIX.—The Foliage of the Locust, ... 310
Plate XXX.—Domberg, a Resort in the Lea of the Zeeland Dunes; A Piece of Reclaimed Marsh Land in Zeeland, ... 312
Plate XXXI.—A Fire-lane in the Pinery on the Dunes of Gascony, 318

Figures in Text.

Page
Figure 1.—Map Showing Forest Zones, ... 182
Figure 2.—Elm-Leaf Beetle; Larva, Pupa and Beetle; from Div. Ent. U. S. Dep't Ag'l, ... 207
Figure 3.—A Spongy Oak Gall: from Riley, ... 208
Figure 4.—A Stick of Oak, Showing Woodpecker Holes, . . . 213
Figure 5.—The Same Stick as Figure 4, Cut Through to Show the Burrow Made by Larva, ... 214
Figure 6.—Goat Moths; Female, Male and Larva: from Riley, . . 216
Figure 7.—Round-headed Apple Borer: from Div. Ent. U. S. Dep't Ag'l, ... 219
Figure 8.—Giant Borers, *Prionus* Species: from Riley, ... 219
Figure 9.—A "Bark-Slipper," *Phymatodes*, sp. in all stages—*larva, pupa and adult*, ... 224

INTRODUCTION.

Relation of Geology to Forestry—Historical Notes on Forests—Present Condition of Forests—Climatic Influence of Forests—Educational and Aesthetical Elements—Protection Against Forest Fires—Duty of the State.

RELATION OF GEOLOGY TO FORESTRY.

The subject of forestry and a report on the forests of the State belong naturally to the work of the Geological Survey, because the forests are related closely to the geological formations, and the Survey has within its scope of investigations the surface formations and the origin of the soils which are natural to these formations. The Division of Surface Geology has been a leading one for the field seasons of 1891 to 1899, and the surveys in this division have covered the State. The forests are the natural vegetal cover of these surface formations, and are characteristic of them. From the geological map, which shows in detail the subdivisions of these formations, and gives their geographic limits, it is possible to learn the general nature of the timber growing naturally on them. The geological map becomes, therefore, the key to the forest map.

The State is marked in its topographic features, which are in some degree the expression of the geologic differences, and diverse forms of the topography affect to some extent the soil conditions and the vegetation. The differences in height are not great enough to make zones of climate, but they have an influence in determining the *habitat* or locality which is favorable to certain species or varieties of trees and unfavorable to others, and in giving character to the forest as an assemblage of trees.

HISTORICAL NOTES ON FORESTS.

New Jersey as one of the Middle Atlantic States was originally well wooded and well watered, and the early settlers within its bounds had to make their clearings on the border of the great continental forests of North America. A pamphlet published in 1648, entitled "A Description of the Province of New Albion," &c., tells of the richness of the soil "replenished with the goodliest woods of oak, and all timber for ships and masts, mulberries, sweet cypresse, cedars, pines and firres."[*] Thomas Budd, in his quaint story of "Good Order Established in Pennsilvania and New Jersey in America," printed in 1685, says: "The *Pine-Tree* groweth here, out of which is made *Pitch*, *Tar*, *Rosin and Turpentine*."[†] Gabriel Thomas in his "West-New Jersey," printed in 1698, says: "In this country also is great plenty of working *Timber*, as *Oaks*, *Ash*, *Chestnuts*, *Pine*, *Cedar*, *Walnut*, *Poplar*, *Firr*, and *Masts* for *Ships*, with *Pitch* and *Rosin* of great use and much benefit to the Country."[‡] In a further account of the many navigable rivers, he says of "Timber-River alias Glocester-River, which hath its name (also) from the great quantity of curious *Timber*, which they send in great Floats to *Philadelphia*, a City in Pennsilvania, as *Oaks*, *Pines*, *Chestnuts*, *Ash* and *Cedars*."[§] The following extract is from the Travels of Johann David Schöpf in the middle and southern United States of North America, in 1777, published at Erlangen, Germany, in 1788.[||] "The mining and metallurgical industry in New Jersey, as everywhere in America, cannot be enduring in its present condition because no care is taken, as is done in most districts in Europe, to maintain the forests, and many works must stop without uninterrupted supplies of coal and timber, as is here and there already the case. There is not the slightest care of the forests. The owners of forges and furnaces have generally large tracts of woodland, which are cut over without order. * * * The

---

[*] Smith's Hist. of New Jersey, Burlington, 1765, pp. 27–28.

[†] Reprint in Gowan's Bibliotheca Americana, No. 4, p. 35.

[‡] An Historical and Geographical Account of the Province and Country of Pennsilvania and West-New-Jersey, London—1698, p. 27.

[§] Gabriel Thomas, page 28.

[||] Reise durch einige der mittleren und südlichen Vereinigten Nordamerikanischen Staaten, Erlangen, 1788, Vol. 1, p 43.

Union, a blast furnace in Jersey, consumed in 12 to 15 years the wood from nearly 20,000 morgen[*] and must be abandoned in consequence of the want of wood. It is true that this cleared land was afterwards settled in farms, but it was not of much value because of the lack of wood. * * * The timber in these mountainous regions consists for the most part of deciduous trees, and mostly of oak, which does not appear to be of very rapid growth in America. * * * There are no forest game regulations; no forest officials in America. Whoever takes up new land acquires full privileges with all on, over and under it. It would not, therefore, be easy to teach the peasants and land-owners by law how to husband their wood so that their great-grandchildren may have a stick of wood upon which to hang their tea-kettle. Want and experience must here replace magisterial foresight. As yet there is no general want of timber. Only in the towns wood is dear because cutting and hauling make the cost four to five times that of standing timber." Thomas Gordon in 1834 said that an "immense forest covers probably four-fifths of the alluvial district; and forty years ago a large portion of it was not worth more than from six to ten cents the acre. * * * They have risen from ten cents, to an average price of six dollars the acre; and, where very well timbered and convenient to market, bring from fifteen to twenty-five dollars. * * * In the sandy region are extensive swamps which bear the beautiful and valuable white cedar, much sought for fencing, and which sells readily at from one to three hundred dollars the acre."[†] These historical accounts show that there was lumbering at an early period in the settlement of the State and that the original timber was large and valuable. Gordon in the above-mentioned description of the State refers to the pine belt as having been largely cut over, owing to the demands of the furnaces, forges, glass-works, and the many steamboats on the rivers. Much valuable wood was consumed as fuel, and the original forest disappeared almost wholly from the lands near navigable waters. The rich agricultural districts had been nearly all taken up in farms at the beginning of the century, and from that time the progress in clearing was probably due to the increasing demand for wood, rather than that for farm-land. The growth of the manufacturing interests and the construction of the canals, and then the railway lines, made the consumption of wood so active that cutting made rapid inroads in the deeper recesses of the forests and the whole State was practically cut over by 1850–1860. Since that time the timber cut has been nearly all of "second growth," and but a small part of it has been merchantable lumber. The disappearance of the large timber has made it necessary to cut over at shorter periods and leave little or no growth to reach mature conditions fit for lumbering.[*] New Jersey has ceased to be a lumber-producing State.

---

[*] Morgen = German acre = $\frac{8}{10}$ acre.

[†] A Gazetteer of the State of New Jersey, by Thomas F. Gordon, Trenton—1834, pp. 2-3.

PRESENT CONDITION OF FORESTS.

The existing conditions of the forests vary greatly in the several great natural divisions of the State. In the farming districts every farm has its wood-lot or *timber land*, which may range from an acre to a hundred-acre tract, or, in some cases, even two or three hundred acres, although these larger tracts are generally outlying and not a part of the farm. Generally they are the home-supply of fuel and fencing-timber and heavier construction-work of the farm and the neighborhood. In these wood-lots the largest and best timber of the State is to be found, and the oak on the limestone and slate of the valleys in Sussex, Warren and Morris counties, on the red-shale in Hunterdon, Somerset, Mercer and Middlesex counties, and on the red-shale and glacial drift soils in Bergen, Essex and Union counties, is thrifty in growth and large. In the clay and greensand marl belts of the State the chestnut predominates. As coppice wood it is rapid-growing and valuable timber. Very little pine timber is in these wood-lots, unless occasionally as the growth on an old field, and rarely any mixed stand of coniferous and deciduous trees. In many cases they are pure forest. These wood-lots are protected against fire by their separate situations, and their owners take care that they are not damaged by cattle running at large and by the careless and malicious acts of trespassers. The forest management in protection is the best, but the treatment is not generally that of a crop, except when the timber is cut or the land is cleared for additional fields. The gathering of the crop is undoubtedly well done and better and more profitable than would be possible under State or any public control of these lots. The weak point in the system or management is the indifference of the owner to the kind of timber and the thickness of the stand of the trees. A careful examination of these lots shows that in many the trees are of inferior kinds, of brushy form and thin stand, allowing of too much undergrowth. At this point scientific forest management would be helpful and the crop would be correspondingly more valuable. Scientific forestry should aid the farmer in caring for wood-lot just as the tillage of the soil and the pasturage of these farms have been improved greatly by the application of the principles of science to agriculture.

---

[*] The largest white-oak tree in the State is in Gloucester County, three miles north of Mickleton, and its dimensions, as given by Dr. J. T. Rothrock, are: Height, 95 feet; diameter of trunk, three feet above the ground, 7 feet 10 inches; spread of branches, 118 feet. The dimensions of the famous Salem white-oak are: Height, 78 feet; circumference, four feet above ground, 18 feet 3 inches; spread of branches, 112 feet; area covered by branches, 9,852 square feet. These trees are older than the settlement of the country and are of the forest which then covered the country.

In the mountainous districts of the State the variation is more in the kind of timber. The Kittatinny mountain has a mixed growth of coniferous and deciduous trees, and also the more rocky parts of the Bearfort and Green Pond mountains. The Highlands forest is nearly all of the broad-leaf kinds, and the chestnut predominates among them. Coniferous trees are scarce. The trap-rock ridges have a more mixed growth on them, and poor in quality. The woodland in these mountainous districts is held generally in large tracts, from several hundred to several thousands of acres, and owing to their size fires occur and burn over large areas, particularly where there are pines in the growth. The damage from cattle and from trespassers also is here felt. Very little of the timber is mature or old, the whole having been cut over since the first settlement of the country, and over large areas there have been repeated cuttings for the fuel used in forges, furnaces and in railway use and other constructions. In the Highlands the losses from fires are comparatively little and the protection is efficient. Here also silviculture might come in to the advantage of the large landholders, and the scientific forester might be helpful in caring properly for the timber, and in cutting so as to promote better successive growths.

The wooded zone of Southern New Jersey, which is known as "The Pines," has some sharp contrasts between its coarse, sandy soils, covered by the pitch pine almost exclusively, its heavier soils with mixed oak and pine, its white-oak bottoms, its white-cedar swamps and its mixed swamp lands. The size of the holdings is large, running up to tens of thousands of acres. The ravages of fire and the severe cutting have left scarcely any large timber, and the original forest has disappeared from these wide stretches of pine lands and cedar swamps. Owing to the frequency of fires over a large part of the Pines belt the timber is oak coppice and stunted pines. The cedar continues thrifty and springs up quickly after cutting. The care of the forest, excepting that of a few individual tracts and of two or three companies, is practically of no value in promoting a better growth, and the lack of some forestal system of protection makes any forestry experiments impracticable.

The forests in the agricultural districts of the State are distributed somewhat irregularly, and the proper proportion of woodland to improved land in farms is not maintained throughout these districts. In some parts of the Raritan valley the cleared area is continuous for miles, and the fringe of trees bordering the brooks is about all that is left of what was a well-wooded valley. The valleys of the limestone and slate in Warren county are also bare of forest. Throughout the southwestern part of the State, and particularly in the greensand-marl zone, the woods are well distributed among the farms and make a pleasing feature in the landscape, as well as answer the needs of forestry in the proper relation of cleared land to forest. [illegible] to let some of the more [illegible] slopes and the steep hillsides be left for planting with [illegible] trees and gullies as well as the [illegible] farming, and allow [illegible] the average size of the [illegible] more intensive farming." [illegible] will add to the real [illegible] of some care were [illegible] valuable timber trees. [illegible] present. An educated [illegible] these lands, which are ill-suited to farming, in forest and the practice of more scientific methods of agriculture must be depended upon to maintain the proper proportion of woodland to farmed lands in these districts of the State.

In the Highlands, on the Kittatinny mountain, on the trap-rock ridges, including the Palisades mountain, and in the Pines belt of Southern New Jersey, there are large tracts which should be kept in forest. General clearing would be unprofitable in the Kittatinny mountain because the surface is too rocky and the soil too thin for making farms on it. The inaccessibility on account of lack of roads and the distance from market, make it ill-suited to agriculture. This mountain range is one of the natural subdivisions of the State which may be considered as adapted to forest—it may be game preserves, or woodland for the production of wood. The Highlands is a well-wooded natural division of the State, and especially the northern part, or about as far south as the line of the Lackawanna Railroad, from Morristown westerly to Hackettstown, and thence to Belvidere. The terminal moraine marks the southern limit of the more densely wooded part. The southern part, stretching southwest to the Delaware river, is more largely in farms and under cultivation. The map which accompanies this report shows the cleared land and the woodland in detail. It may be noted that the slopes of the hills and mountains, and the mountain-tops are generally wooded; the farm-lands are in the valley-bottoms, and on the level plateaus. The timber is generally chestnut and oak and other broad-leaf species. In places chestnut coppice wood predominates over all other kinds. There is less white oak, hickory and ash than on the limestone and slate of the Highland valleys and the Kittatinny valley. Black walnut, tulip poplar and beech are scarce. The coniferous trees are white pine, pitch pine, hemlock, larch and red cedar. The value of this Highlands forest is in the favorable conditions which it makes for gathering ground for the streams supplying water to the cities of the northeastern part of the State. The brooks in the woods do not carry so much earthy material as streams which receive water from bare ground and ploughed fields. The water is clear and not turbid or roily and is suited to city supply. The superior quality of water from such wooded districts, over that gathered in a cleared farming country, makes it

The wooded zone of Southern New Jersey, which is known as "The Pines," has some sharp contrasts between its coarse, sandy soils, covered by the pitch pine almost exclusively, its heavier soils, with mixed oak and pine, its white-oak bottoms, its white-cedar swamps and its mixed swamp lands. The size of the holdings is large, running up to tens of thousands of acres. The ravages of fire and the severe cutting have left scarcely any large timber, and the original forest has disappeared from these wide stretches of pine lands and cedar swamps. Owing to the frequency of fires over a large part of the Pines belt the timber is oak coppice and stunted pines. The cedar continues thrifty and springs up quickly after cutting. The care of the forest, excepting that of a few individual tracts and of two or three companies, is practically of no value in promoting a better growth, and the lack of some forceful system of protection makes any forestry experiments impracticable.

The forests in the agricultural districts of the State are distributed somewhat irregularly, and the proper proportion of woodland to improved land in farms is not maintained throughout these districts. In some parts of the Raritan valley the cleared area is continuous for miles, and the fringe of trees bordering the brooks is about all that is left of what was a heavily-timbered valley. The valleys of the limestone and slate in Warren county are also bare of forest. Throughout the southern-central part of the State, and particularly in the greensand-marl zone, the woods are well distributed among the farms and make a pleasing diversity in the landscape, as well as answering the claims of forestry in the proper relation of cleared land to forest. It would be well in places to let some of the more rocky hill-tops and the steep hill-sides be left for planting with valuable timber trees, and the ravines and gullies as well as the thin soils, which are too poor for profitable farming, and allow them to grow up in wood. A reduction in the average size of the farms would lead to what is termed "more intensive farming," and the increased acreage in woodland would add to the total production by its crop of timber, particularly if some care were taken in seeding the wood-lots with more valuable timber trees, and the cuttings were not so severe as at present. An educated public opinion favoring the keeping of these lands, which are ill-suited to farming, in forest and the practice of more scientific methods of agriculture must be depended upon to maintain the proper proportion of woodland to farmed lands in these districts of the State.

In the Highlands, on the Kittatinny mountain, on the trap-rock ridges, including the Palisades mountain, and in the Pines belt of Southern New Jersey, there are large tracts which should be kept in forest. General clearing would be unprofitable in the Kittatinny mountain because the surface is too rocky and the soil too thin for making farms on it. The inaccessibility on account of lack of roads and the distance from market, make it ill-suited to agriculture. This mountain range is one of the natural subdivisions of the State which may be considered as adapted to forest—it may be game preserves, or woodland for the production of wood. The Highlands is a well-wooded natural division of the State, and especially the northern part, or about as far south as the line of the Lackawanna Railroad, from Morristown westerly to Hackettstown, and thence to Belvidere. The terminal moraine marks the southern limit of the more densely wooded part. The southern part, stretching southwest to the Delaware river, is more largely in farms and under cultivation. The map which accompanies this report shows the cleared land and the woodland in detail. It may be noted that the slopes of the hills and mountains, and the mountain-tops are generally wooded; the farm-lands are in the valley-bottoms, and on the level plateaus. The timber is generally chestnut and oak and other broad-leaf species. In places chestnut coppice wood predominates over all other kinds. There is less white oak, hickory and ash than on the limestone and slate of the Highland valleys and the Kittatinny valley. Black walnut, tulip poplar and beech are scarce. The coniferous trees are white pine, pitch pine, hemlock, larch and red cedar. The value of this Highlands forest is in the favorable conditions which it makes for gathering ground for the streams supplying water to the cities of the northeastern part of the State. The brooks in the woods do not carry so much earthy material as streams which receive water from bare ground and ploughed fields. The water is clear and not turbid or roily and is suited to city supply. The superior quality of water from such wooded districts, over that gathered in a cleared farming country, makes it desirable that the forests in the Highlands should be kept, and not be cleared and put in farms. The tillage and pasturage of the flats and of the level tops may be unobjectionable; the slopes of the mountains and the steep hillsides should not be cleared, but be kept in woods. The need of all the water of this Highlands region, within the next half century, by our cities and towns, emphasizes the value of the water-supply which it has, and the necessity of keeping it in large part in woodland for the quality of the water as well as the quantity. The Pines Belt of Southern New Jersey also has an important relation to the great question of public water-supply, and the cities and towns on the Delaware river and the sea-side towns on the ocean-front are yet to get their water from this broad zone of the Coastal Plain, watered by many streams now well fed from the never-failing and equable flow out the pure sands and gravels of these beds of late geological age. The capacity of this South Jersey region to supply water of excellent quality and with steady flow, makes it valuable as a preserve or reservation for this use, aside from the lumber and timber which might be produced, were it not for the fires which consume trees and soil and leave barren sands exposed to the dangers of moving by the wind. The forest question is here all-important, but the production of wood as a crop is not so essential to the conservation of the water-supply as the maintenance of a cover of trees and shrubs.

CLIMATIC INFLUENCE. OF FORESTS.

The relation of forests to climate is close and yet is not capable of expression in exact terms, because of the great variation in the working of the agents which make our climates and their great effects, in comparison with the lesser influence attributable to the forest. On continental plains and near great oceans the influences of great land-masses or of wide water-areas are so great in their sweep that the relatively insignificant cover which even a tall forest may afford is a small factor in the making of climate. The islands in the ocean, *e. g.* Great Britain and Ireland, have an insular climate which no extent of woodlands could alter greatly. Our continental climate also is determined by topographic and not by forestal conditions. The forest is, however, a shade to the ground, and protects against what is termed insolation or excessive heating by the rays of the sun falling directly upon it. The influence in lessening the quantity of water evaporated from the surface also is recognized, although it is offset by the transpiration of water by the leaves of the tree and drawn up by the tree from the ground-water. The most important beneficial influence of the forest is as a wind-break, and in reducing the sensible effects of extreme heat and severe cold. The moderating and softening influences of forests are known, but are not so well recognized as they ought to be by students of climate and by the people generally. The shelter of a narrow belt of trees or of woods against the dry parching winds of summer and the cold waves of winter is not only a comfort to man, but also a protection to many of the more delicate forms of vegetation and to some farm crops. Hence the value in an agricultural district of wood-lots which may serve as wind-breaks. In sandy soils high winds tend to move the loose grains and to form shifting bodies of sand or dunes, which bury vegetation in the march and tend to produce conditions like those of a desert. Hence in a country whose surface is sandy, as that of southeastern New Jersey, timber belts are necessary to arrest this movement. Frequent fires have, in places, made so barren a soil that this desolating dune-formation is appearing and is threatening to widen its reach.

The influence of the forest upon the stream-flow of any country is mainly upon the discharge or rate of flow, and not upon the total volume of water which runs off in the streams, and the layer of vegetable mold or humus of the soil is in the nature of a sponge, taking up the water and holding it, thereby reducing the flow in the case of light rains and yielding a constant supply after heavier rainfalls.* The study of the subject of stream-flow in New Jersey points to the necessity of a forest cover in order to protect the soil and prevent it being carried away into the streams, and making the water turbid and filthy, and in providing a bed of leaf-mold and humus to hold the water against too rapid discharge in ordinary floods. The beneficial effects are sufficient to call for some restriction upon further and extensive clearing.

---

* The woodlands of our day are largely of coppice growth and of small trees as compared with the giants of the original forest. The layer of humus was then large, due to the accumulation of decaying tree-trunks and the litter of many seasons, and the more dense growth of ferns and other shade-loving plants. The thicker bed of humus was able to hold a larger volume of water and its influence was correspondingly greater than it is to-day, when the forest litter is scanty—perhaps the growth of a few seasons only. Fires burn over woods so frequently that there is practically no humus such as the original forest had. The total area of swamps also has been reduced largely and the catchment basins are now mountain-tops and hillsides, rather than valleys and swamps.

EDUCATIONAL AND ÆSTHETICAL ELEMENTS.

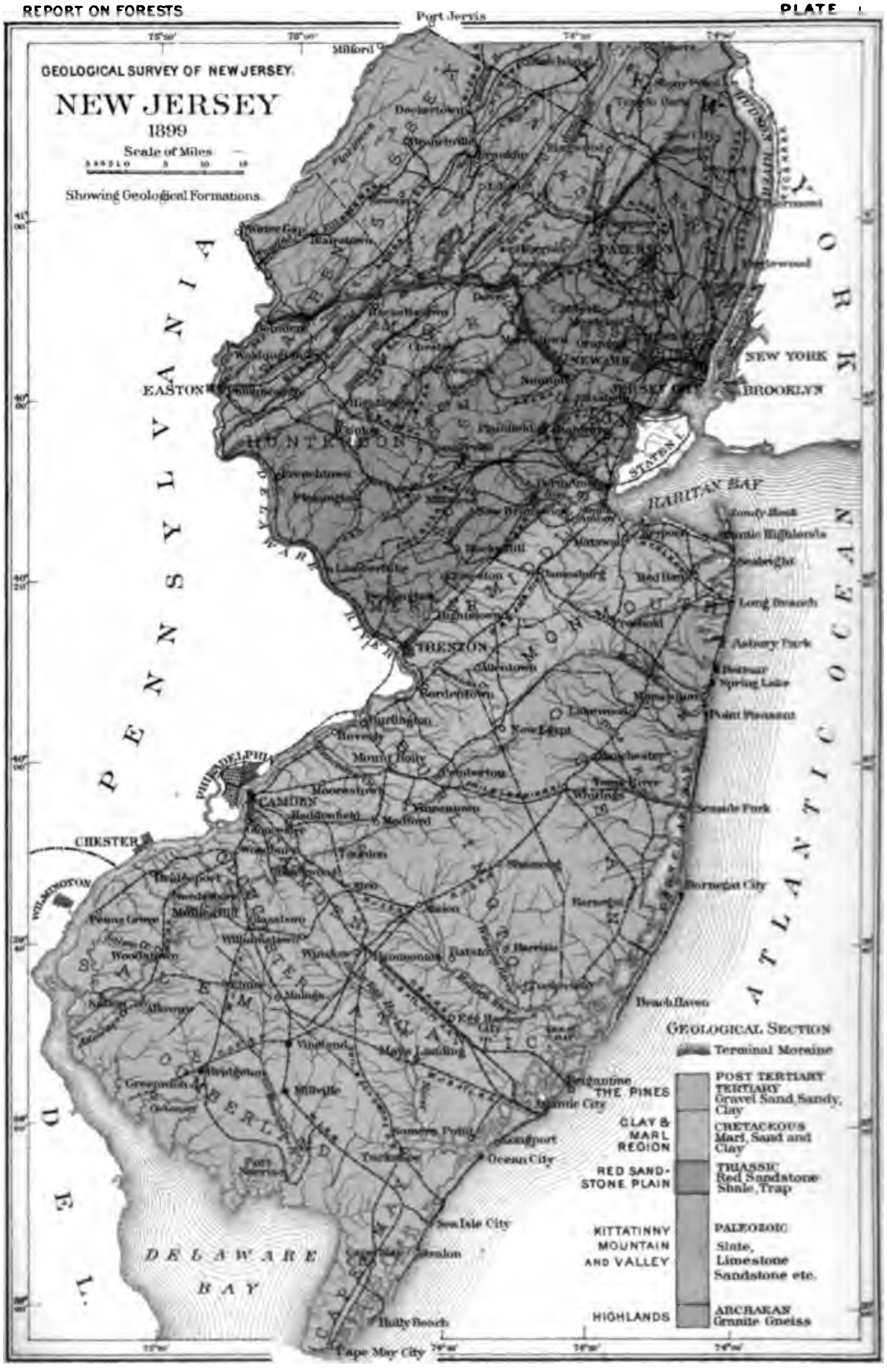
The preservation of some of the forests for the purposes of education is of public importance. To the student of botany the woodland must always be the place for earnest work and full of fruitful suggestions and valuable facts. There trees, shrubs and herbaceous plants are found in their native *habitat*, and their relations to one another are there studied to the best advantage. The clearing of all the country around our large towns and cities makes it necessary now to go far afield to study the flora of the natural woods. The reservation of tracts of woodland in easily accessible locations will help to counteract the losses due to so wide clearing of the forest, and will make it possible for the scholars of city schools to study how plants and trees grow in their native woods. The text-book cannot take the place of living forms. The woods should be kept as nature's arboreta for the benefit of the schools.

The preservation of typical species of the plant-world and also of those which are characteristic of any locality or district, as the mountain tops, the sheltered valleys of the Highlands, and the swamps and sandy plains in Southern New Jersey, calls for the preservation of some of the forests. Extensive clearing threatens to exterminate some of the more rare and more interesting species and to break up the grouping of forms as they are now to be seen in these wild conditions of the forest. It would be a public misfortune to lose any of our characteristic species or their natural grouping, as now existing, or to have our rich botanical heritage marred by general deforestation of the State.

The woodlands afford homes to our characteristic animals. They are great natural preserves where the mammals, birds and other forms native in the State are found. The clearing of the timber means the extinction or disappearance of some of our wilder species from the State. The protection of our fauna is bound up with the preservation of the forests, and the student of natural history is deeply interested in this protection. The question of preserves for game also comes in as of importance, and the sportsman as well as the naturalist wants the woodland and is the friend of protection for the forest.

PROTECTION AGAINST FOREST FIRES—DUTY OF THE STATE.

The protection of the forests demands the care of the community and the State in stopping the fires which are caused by carelessness, malice and avoidable accidents. The great Pines district of Southern New Jersey should be protected against fires. The forests of the Highlands should be protected against excessive wasting and clearing on account of their value to the public water-supply. For the encouragement of this retention of the land in wood there may be a bounty-system or rebate of taxation. The owner of woodland who derives no regular income from it and has no yearly crop might be exempted from taxation so long as the timber was uncut, or might be obliged to pay a percentage of the revenue whenever his woodland was cleared. In this way the hillsides and the more inaccessible tracts might be kept in wood. On the Blue or Kittatinny mountain the protection against fires is demanded, because of the easy inflammability of the pitch pine, and the dry condition of the pine and deciduous-tree leaves in the autumn and in the spring. In the southern part of the State the necessity of public protection is imperative if there is to be any production of timber or lumber in that part of the State. Both Mr. Pinchot and Mr. Gifford have recommended fire-lanes. Mr. Gifford's suggestion that these lanes be also public roads, and possibly State roads, is a good one so far as protection goes. Some system of protection must be adopted if ever these terrible forest-fires are to be stopped. If State reservations are to be created these three great divisions or districts are the ones in which they are to be located. A forest system with State control must mean State ownership of lands in order to be effective in either protection or in the cultivation of wood as a crop in silviculture. The control of the forests by the State is a subject of great public importance and demands the careful study of the wise legislator, in order to avoid the error of excessive paternalism in government on the one hand and the reckless and riotous excesses of individual liberty and license on the other side. It is the province of this report to give information, but at the same time it is the part of wisdom to urge that the State shall take care to inculcate sound moral instruction as well as give valuable facts. The education of the people is not wholly one of technique. The State is responsible for order as well as sound learning, and the education or uplifting of the moral sentiment is as essential as that of mere schooling in the facts of science. The people must be taught to recognize duty to the State as well as to individual, and no amount of technical education is of force to save the forests unless the interest of the individual coincides with that of the State Hence an educational campaign is desirable. The State ought to continue the work of giving information about forests and forest management and protection, and also aim to create a public sentiment which shall compel the local authorities in the more densely wooded districts to stop forest fires and lead to a better care of woodland and to the restoration of the forest over lands which are not of value in tillage or pasturage in farms Inasmuch as these surveys of the forests of the State were begun by the Geological Survey, the continuation of the work and of this educational campaign could be directed by the Board of Managers of the Survey as a Forest Commission and be done by an expert forester under the direction of said Board. The duties of this forester would be like those of State Foresters in States which have such offices, and would be largely in collecting information and in distributing it by correspondence and by public lectures, bulletins and annual reports.


GEOLOGICAL SURVEY OF NEW JERSEY.
NEW JERSEY
1899
Scale of Miles
Showing Geological Formations.
Port Jervis
Milford
Deckertown
Branchville
Newton
Water Gap
Blairstown
Hackettstown
Dover
Belvidere
Washington
Phillipsburg
EASTON
Morristown
PATERSON
NEWARK
Orange
JERSEY CITY
NEW YORK
BROOKLYN
STATEN I.
Plainfield
Flemington
Frenchtown
HUNTERDON
Somerville
New Brunswick
Perth Amboy
RARITAN BAY
Sandy Hook
Atlantic Highlands
Seabright
Red Bank
Long Branch
Asbury Park
Freehold
Matawan
Princeton
Lambertville
Hightstown
TRENTON
Allentown
Bordentown
Burlington
Mount Holly
Pemberton
New Egypt
Lakewood
Manasquan
Point Pleasant
Spring Lake
Lakehurst
Toms River
Whitings
Seaside Park
Barnegat City
PHILADELPHIA
CAMDEN
Moorestown
Haddonfield
Medford
CHESTER
WILMINGTON
Woodbury
Bridgeport
Penns Grove
Woodstown
Swedesboro
Glassboro
Williamstown
Hammonton
Batsto
Elmer
Malaga
Salem
Alloway
Vineland
Mays Landing
Egg Harbor City
Tuckerton
Beach Haven
Brigantine
Atlantic City
Somers Point
Longport
Ocean City
Tuckahoe
Millville
Bridgeton
Greenwich
Port Norris
Sea Isle City
Avalon
Holly Beach
Cape May City
P E N N S Y L V A N I A
D E L.
DELAWARE BAY
ATLANTIC OCEAN
N E W Y O R K
GEOLOGICAL SECTION
Terminal Moraine
THE PINES
POST TERTIARY
TERTIARY
Gravel Sand, Sandy, Clay
CLAY & MARL REGION
CRETACEOUS
Marl, Sand and Clay
RED SANDSTONE PLAIN
TRIASSIC
Red Sandstone Shale, Trap
KITTATINNY MOUNTAIN AND VALLEY
PALEOZOIC
Slate, Limestone Sandstone etc.
HIGHLANDS
ARCHAEAN
Granite Gneiss

PART I.

The Forests of New Jersey

By C. C. VERMEULE.

Physical Condition of New Jersey Forests.

The term "forest," as used in this paper, includes all areas which are devoted to the growing of timber, whatever may be the stage of growth. The forest area is therefore made up of stump land, brush land and timber of all ages, but the amount of stump and brush land is comparatively small, and only a small proportion of the timber exceeds fifty years in age; much the larger part ranges from 20 to 50 years. While the forest growth varies in thriftiness with the nature of the soil, practically all of the upland, if left uncultivated or unoccupied, will produce timber, consequently, exclusive of the areas occupied by towns and cities, all of the upland not under cultivation may be considered to be forest. The tide-marsh areas cannot produce timber because of saltness; there are small areas of savannah land naturally treeless in the southern New Jersey pine belt, but the kind of alluvial lands which will not produce timber because of the exceeding fineness of the soil, such as the prairie lands of the Mississippi Basin, are almost unknown in this State.

The most considerable area of upland which seems almost incapable of producing timber is that known as "the plains," in the southeastern part of Burlington county, comprising over 14,000 acres of sandy and gravely upland, covered with a stunted arboreal growth, and which is fully described in a later chapter. In northern New Jersey most of the top of Bearfort mountain, and some limited areas of Green Pond and Copperas mountains, together with the main crest and steep eastern escarpment of Kittatinny mountain, are too bare of soil to produce timber of consequence, but all of these barren areas together do not comprise one per cent. of the upland area of the State.

DISTRIBUTION OF FOREST.

The largest continuous area of forest in the State is "the pines," an almost unbroken coniferous forest, covering practically all of that portion of the State southeast of a line drawn from Seabright to Glassboro and thence through Bridgeton to Delaware bay, and comprising some 1,200,000 acres in all. The greatest body of deciduous forest lies on the northeastern Highlands, nearly co-extensive with the Wanaque, Pequannock, Rockaway and Upper Musconetcong water-sheds. Another considerable area is that of the higher portion of the Kittatinny mountain region.

The following table shows the area of forest by counties:

AREA OF FOREST BY COUNTIES.

COUNTY.	Cleared Upland, Acres.	Forest, Acres.	Percentage of Upland in Forest.	Prevailing Kinds.
Atlantic, . . .	35,771	271,638	88	Coniferous
Bergen, ...	85,879	57,591	40	Deciduous.
Burlington, . .	207,979	303,777	59	Coniferous, south. Deciduous, north.
Camden, . . .	72,513	66,588	48	Coniferous, east. Deciduous, west
Cape May, . .	29,823	80,851	73	Coniferous
Cumberland, .	101,316	166,264	62	Coniferous, east. Mixed west.
Essex, ...	52,507	24,239	32	Deciduous.
Gloucester, . .	126,685	74,818	37	Coniferous, deciduous and mixed.
Hudson. . . .	15,073	713	05	Deciduous.
Hunterdon, . .	240,438	39,481	14	Deciduous.
Mercer, . . .	128,400	15,829	11	Deciduous
Middlesex, . .	131,276	60,164	31	Deciduous.
Monmouth, . .	211,288	89,711	30	Deciduous, north. Coniferous and mixed southeast
Morris, ...	163,809	140,101	46	Deciduous.
Ocean, ...	47,084	313,087	87	Coniferous.
Passaic, ...	50,284	75,204	60	Deciduous
Salem.	138,081	50,057	27	Deciduous except extreme east
Somerset, . . .	166,352	28,613	15	Deciduous.
Sussex, ...	201,855	136,538	40	Deciduous
Union, ...	46,954	14,350	23	Deciduous.
Warren, ...	171,564	60,205	26	Deciduous
The State .	2,424,931	2,069,819	46	

The above areas were determined by actual measurement of the forest areas laid down on the topographical maps of the

State. Small groves, less than ten acres in extent, and strips, hedge-rows, etc., are not included. A table of areas, by townships, will be found in the "Physical Geography of New Jersey," pages 134 to 149 of the Appendix.

It will be seen that 46 per cent., or nearly half of the upland area of the State, is in forest. The improved land in farms, according to the census of 1890, aggregates 1,999,117 acres—almost exactly equal to the forest area. Compared with neighboring States, we have the improved land in farms and forest area as follows:

	Percentage of Upland Area Improved.	Estimated Percentage of Upland Area in Forest.
New Jersey,	46	46
Massachusetts,	41	51
Connecticut,	53	39
New York,	58	34
Pennsylvania,	47	45
Delaware,	60	32
Maryland,	53	39

This shows that New Jersey has more than the average amount of forest area, although, as may be seen by consulting the areas by counties, it is not evenly distributed.

By geological and topographical divisions the forest areas are as follows:

	Forest Area. Acres.	Percentage of upland area in forest.
Kittatinny Mountain, including all west to Delaware River,	58,000	64
Kittatinny Valley,	40,000	19
Northeastern Highlands,	211,000	67
Southwestern Highlands,	89,000	30
Northeastern Red Sandstone,	103.000	31
Southwestern Red Sandstone,	91,800	14
Clay and Marl Region,	147,840	15
Tertiary and Quaternary,	1,329 179	68

The map showing the distribution of forest and its relation to the stream catchments, which accompanies this report, gives in further detail the location of the forests of the State. This map shows the acres of forest in each one hundred acres of upland. It will be seen that the most completely deforested sections—containing less than 10 acres of forest in 100 acres of upland—are not, as might at first be supposed, in the most populous regions, but in the agricultural sections, viz., the Raritan valley, in Somerset and Hunterdon counties, and thence southward in a belt about 12 miles wide along the Delaware river, in Mercer, Burlington, Camden, Gloucester and Salem counties. Other deforested areas are the Musconetcong, Pohatcong and Delaware valleys, in Warren county, and about the Navesink and Shrewsbury rivers, in Monmouth county.

CHANGES IN FOREST AREA.

A period of from 12 to 20 years has elapsed since the original topographic survey of the State was made. Since that survey gave the area of forest it has been possible to compare present conditions with those of 16 years ago. This comparison shows that the amount of forest which has been cut off and cleared up for cultivation in northern New Jersey is very insignificant, and is offset by the clearings which have been abandoned and allowed to grow up. Taking the State as a whole, there is nearly as much forest to-day as there was in 1860. In this connection the following data from the United States census are instructive:

	1850.	1860.	1870.	1880.	1890.
Total land in farms, acres, ...	2 752,946	2 983.525	2,989.511	2,929.773	2,662 009
Improved land in farms, ...	1.767 991	1,942,281	1,978.067	2,097,719	1,999.117

These figures show practically no increase in the land under cultivation since 1860, and a decrease of 320,000 acres in unimproved land in farms.

Analyzing the changes in forest area, we find that there was progressive deforestation in all portions of the State up to 1860, although the rate was most rapid from about 1830 to 1850, and very slow in many counties after the latter date. Monmouth, Mercer, and all counties farther north excepting Sussex, show stationary forest area after 1860. There has been some clearing in the Kittatinny and Delaware valleys, in Sussex county, since 1860, amounting to 27,000 acres, or about one-fifth of the forest area. In all of the other northern counties the new clearing has not more than equaled the abandoned clearings which have grown up again. Where there has been a considerable loss in area of improved land in farms it may be traced to growth of cities.

In all of the southern counties, south of Monmouth and Mercer, there has been steady clearing. These counties show an increase in improved farm land since 1860 amounting to 173,000 acres, or about 13 per cent. of the forest area has been cleared. Ocean county has lost about 4 per cent. of its forest area, Burlington 12 per cent., Atlantic 4 per cent., Camden and Gloucester 17 per cent., Salem 30 per cent., Cumberland 21 per cent., and Cape May 13 per cent. This clearing has been mostly on the clay and marl belt, and the western border of the pines, extending well into the pine region in Cumberland, and about Vineland, Hammonton and Egg Harbor City.

The decrease in unimproved land in farms is explained by some of this clearing-up of land in southern counties, but also to a considerable extent by the abandonment of unproductive farms containing a large proportion of unimproved land, which is evidenced in the pines in Ocean, Burlington and Atlantic counties and also in the extreme north, in the hilly portion of the State.

CHANGES IN PHYSICAL CONDITION.

Although the area of forest has not sensibly diminished in northern New Jersey, and has decreased only about 13 per cent. in the southern counties since 1860, it may be thought that the proportion of brush, stump land and small timber is considerably greater now than at the middle of the century. We have investigated this question with some care. So far as may be determined from extended personal observation, the deciduous timber of the State has generally increased in size and improved in quality since the period of the topographic survey, from 1880 to 1886.

In the Highlands and Kittatinny valley regions there has been no severe cutting during the last fifteen years. Considerably less timber has been cut than during the previous fifteen years. A considerable amount of timber was formerly cut at an age of from 20 to 25 years, or even less, for charcoal, cordwood, hoop-poles, etc. The profit in this has grown less and the owners are more alive to the greater returns to be had from a larger growth. Chestnut can be most profitably cut at from 35 to 40 years old. If left standing longer, the coppice wood is said to sometimes decay at the heart. It is maintained that a growth of this age will yield as much wood per acre as the original forest. Oak can be profitably left until 50 to 60 years old. The growth of all the deciduous timber is most rapid before reaching 40 years, and if it is merely a question of the amount of wood, no doubt the largest yearly returns come from cutting at 40 years, but the larger timber is suited for more valuable uses and will bring more money per cubic foot. Thus 100 telegraph poles from an acre of timber 35 years old may be worth $400, while if left until 50 years old they might easily be worth $800 to $1,000. For railroad ties there is little advantage gained after 40 years is reached. But there is now much timber on the Highlands and Kittatinny mountain upwards of 40 years old, and a very large proportion ranges from 40 to 50 years of age.

We have the testimony of many experienced men in this region that the forests are to-day in much better condition than they were from 1850 to 1860. This is borne out by the comparative scarcity of trees over 50 years old and the abundance of those 40 years old. We may confidently place the period of maximum deforestation at about 1850. We are told that about this time large areas of the Highlands presented a perfectly bare appearance. The cause was partly the large use of charcoal by the forges and furnaces then scattered all over northern New Jersey, and partly the fact that anthracite coal was not yet in general use, and the use of wood and charcoal for domestic fuel, and by the railroads and manufacturing establishments, was general. Moreover, although the population of New York, Philadelphia and the cities of New Jersey was much less than now, these cities were more dependent upon the near-by fuel and timber-supplies than at present, as facilities for transportation were very inferior.

As for the use in iron-making we find that about 1855 it is estimated that 100,000 tons of ore were used. A fair estimate for the larger furnaces is 65 bushels of charcoal to one ton of ore. No doubt the small forges used more than this, but even at this rate 6,500,000 bushels would be required, which would mean that fully 6,500 acres of timber, or six square miles, must be cut annually for use in the iron industry alone. This demand began to disappear in 1850, owing to the introduction of anthracite blast-furnaces, although some forges continued in operation 15 years later, and a very few up to 1880.*

Add to this large use the fact that the larger timber was being steadily cut off for sawed lumber, that much charcoal was used for domestic and other purposes, and the other demands which we have noted, it is easily seen how severe was the cutting of Highlands forests, when the charcoal iron industry was most active, at about 1850.

Since that time the cutting of very young timber, such as is suitable only for charcoal, cordwood or hoop-poles, has become less and less profitable. It must now be allowed to attain an age of 35 to 40 years at least, so as to be useful for railroad ties or telegraph and telephone poles.

Some portions of the Highlands have been cut over so frequently that there is evidence that the chestnut timber is suffering from the need of re-planting. Coppice wood will gradually deteriorate, and in some places it is said to rot at the heart at an early age. Some of the complaints may indicate that the soil is becoming exhausted, for there is no reason to expect that soil can produce repeated growths of timber without being deprived of its fertility. The production of one cord of wood yearly, containing about one and one-half tons of dry solid matter, together with the leaf crop of the trees, is certainly as great a tax upon the acre of land as is the production of the average one and one-half tons of hay or other farm crops. There are also instances noted where a growth of oak cut off has failed to reproduce itself, but red cedar has come up instead. But these evidences of deterioration are exceptional, and generally confined to districts which have been most frequently cut in the past. In general the forests of the Highlands and Kittatinny valley, although they contain little timber over 50 years old, may be pronounced luxuriant and in better condition than they were 40 to 50 years ago.

In the red sandstone country there is likewise no evidence of deterioration, and the same may be said of the clay and marl region. The forests here consist almost exclusively of small parcels attached to farms. They are utilized mainly in connection with the farms, furnishing fuel, fencing and an occasional stick of timber. Ten acres of forest so utilized is a most valuable asset on a farm of one hundred and fifty acres. From appearances the 14 or 15 acres per 100 acres of upland in these regions have more than sufficed for the farmers' need, and the forest has gone on increasing until these farm-parcels contain some of the best timber in the State. This is especially true of the red sandstone in Middlesex, Somerset, Hunterdon and Mercer counties. When it becomes so large and valuable that the lumberman's offer is too tempting, the steam saw-mill does its work and the timber is cut off. This is to be expected. These proprietors know the value of and appreciate the beauties of their woodlands, but it is good business with them to utilize and convert into money all the products of their lands. So when the forest crop is ripe it is gathered, the entire piece then being cut off. Some of the timber on the trap ridges is small and poor in quality, but the soil there is poor and there is little evidence that the timber is anywise inferior to that of 50 years ago.

---

* For a list of forges and charcoal furnaces see Annual Report of the State Geologist, 1879.

In the pines the forest may have deteriorated because of forest fires. There is evidence that these fires have occurred from the very discovery of the country, but it is natural to suppose that the introduction of many miles of railroad, and of an increasing population, into this district have increased the number of forest fires considerably. Some deterioration may, therefore, be conceded, but there is not much proof that it has been such as to cause radical changes in the character of the forest. We have less data of the former condition of this timber than for the deciduous forests. There were some 25 forges and furnaces in this region in 1850, together with a large number of saw-mills, now abandoned, and these must have made some inroads into the forest.

As tending to corroborate the decreased cutting of timber over the State in general, it is interesting to note that, during a canvass of the water-powers of the State, made about 1892, for the Report on Water-Supply, we found 75 abandoned saw-mill sites, to which must be added several sites originally used for saw-mills, but now utilized for other manufacturing, and also a number of sites known to have once been occupied of which no trace now exists. Certainly over 100 water-powers once utilized for sawing lumber are no longer in use for that purpose.

Reviewing all of the evidence which we have collected, therefore, we state with confidence that there was progressive cutting and clearing-up of the original forest all over the State, from its settlement until 1860, but that at the latter date very little original forest remained. This cutting was most severe about 1850, and from 1850 to 1860 was the period of maximum deforestation. The forest was then younger and smaller, with a larger proportion of stump and brush land than has prevailed at any time since. The cutting of very young growth has decreased to a marked extent in recent years, and the average size and age of the forest has increased. At present not two per cent. of the forest is cut annually, so that at the present rate of cutting all of the forest may attain an age of fifty years.

VALUE OF FOREST PRODUCT.

It is not easy to arrive at an accurate valuation of the forest product of the State. Much of the product is used directly on the farms where it is cut, as fuel or for fencing; there is also a ready sale for railroad ties, telegraph and telephone poles, piling, etc., in all parts of the State, and these products do not go to the mill, but usually quite direct from the owner or lumberman to the consumer.

We estimate that the consumption for domestic fuel at present is 752,000 cords, and for fuel in glass-works and brick-kilns, etc., 45,000 cords, or about 800,000 cords consumed as fuel. There is a rule commonly accepted among the forest owners that the forest will produce one cord of wood for each year that it has been growing. This seems a fairly accurate average for the deciduous forest from 30 to 50 years old, but too high for the pines. Adopting this figure, the above fuel-consumption will absorb the yearly product of 800,000 acres of forest. It may be estimated to be worth $400,000 on the stump and $2,400,000 in the market at the point of consumption.

The Report on Water-Supply, 1894, gave 261 saw-mills and wood-working establishments run by water-power, using 4,085 net horse-power. It will be seen that these are small establishments, using an average of only 15.6 horse-power each, but they all contribute to the lumber product. The most effective work is now done, however, by the portable steam saw-mill set up in the woods. The entire lumber product, from logs and bolts, was valued in 1890 at $1,215,524, and the raw material used at these mills at $692,537. Some of this undoubtedly came from other States to the mills along the Delaware.

The steam railroads and trolley-roads of the State use fully 1,250,000 ties annually in new construction and renewals. At 50 cents each, this affords a market for $625,000 worth of forest product, but by no means all of these ties come from the forests of this State, many being brought from other States. A growth of oak and chestnut from 35 to 40 years old should produce from 250 to 500 ties per acre. Taking 375 ties as the average, there will be a value of $187.50, to which must be added about 15 cords of wood, worth $45, or $220.50 per acre in all, for the product delivered to the consumer. From this must be deducted the cost of cutting, hewing and hauling, together with freight on the cordwood.

The consumption of telegraph, telephone and trolley-poles within the State may be estimated at 14,000 poles annually, worth from $2 to $10 each, and probably averaging $4, or $56,000 in all, besides a large market in adjacent towns.

There is also a steady demand for piling about the docks and wharves. The railroad ties, telegraph, telephone and trolley poles and piles are readily marketable, and require no manufacture save some little hewing and trimming with the axe in the forest.

The market afforded within the State for the manufactured forest-product is therefore made up about as follows:

	Value
Logs and bolts at mill, ...	$692,537
Railroad ties, ...	625,000
Telegraph, telephone and trolley poles and piling,	100,000
Fuel for domestic consumption and brick and tile manufacture, ...	2,400,000
Fencing, not including sawed lumber	365 000
Total, ...	$4 182,537

Some of the above comes from other States, as we have remarked, but there are other products, such as charcoal, which we have omitted and cannot well estimate. On the whole the forest product, not including manufactured material, may be taken to be worth nearly $4,000,000 annually.

Assuming all of the above to be cut from timber 50 years old, yielding 40 cords per acre, or 5,000 feet B. M. of merchantable lumber, about 30,000 acres would need to be cut annually, and 1,500,000 acres would keep up the supply. The results of our surveys indicate that, taking the State as a whole, the timber is not being cut at a more rapid rate than this. The owners are finding it more profitable to allow the timber to attain an age of from 35 to 50 years than to cut it younger.

VALUE OF STANDING TIMBER.

Careful inquiry as to the value of standing timber of various ages has been made. The variation is rather wide, according to the character of the growth and its accessibility to market. In the Kittatinny valley and Highlands the value of stump land, where land is valuable only for forest, ranges from $1 to $5 per acre; timber 30 years old, from $10 to $30; 50 years old, from $25 to $50, with instances of exceptionally good or well-located timber selling as high as $100. Timber classed as heavy, usually upwards of 60 years old, ranges from $60 to $100, but is scarce in the Highlands, where very little timber exceeds 50 years in age. A fair average value for all forest in this region is $25 per acre. In the red sandstone and Cretaceous regions the value of good land for farming or other purposes is often considerable, and it is difficult to determine the value of the timber apart from the land, but it averages older and heavier than that of the Highlands, and even for the same age is more valuable. Timber 30 years old may be taken to be worth from $25 to $50 per acre, while that classed as heavy ranges from $50 to $150 per acre. Perhaps the average value of all forest in these regions may be taken to be $40 per acre on the red sandstone and $35 for the clay and marl region.

In the Pines a number of answers to inquiries give the value of stump or brush land at from 10 cents to $5 per acre where it is valuable only as forest. Its value over a large part of the district is purely nominal. A growth of pine 30 years old is valued from $5 to $25 per acre. Mr. Pinchot, in his interesting valuation surveys appended to this report, gives the amount of cordwood on some sample plats near Whitings. This timber had not been injured by fires and was a second growth of pine from 35 to 40 years old. One plat gave 13 cords per acre and another 7 cords, there being practically no merchantable timber. At 50 cents per cord this corresponds to a value of from $3.50 to $6.50 on the stump. Forest which has been fired is worth much less, and it would seem that a value of $25 for pine 50 years old is rather exceptional.

The value of pine 50 years old, as returned by correspondents, ranges from $10 to $100 per acre. Referring again to Mr. Pinchot's returns for old forest, the average of 12 acres at Winslow we estimate to be worth $46 per acre on the stump, and the average of 5 acres at New Lisbon $30.50 per acre. Both of these are exceptionally good timber, and have not been injured by fire. A second growth of pine at Whitings, 50 to 60 years old, is, on the basis of Mr. Pinchot's returns, worth $16 per acre. This, also, has not suffered from fire.

It would seem, therefore, that, exclusive of the value of the land, the best of the pine forest ranges in value from $16 to $46 for an age of 50 years upward. And the range is from these figures down to nothing, with much the larger part of the area worth less than $10 per acre. For the entire area the pine forest will not average above $10 per acre, land and timber included. Of course, in certain localities this pine forest is worth more for other purposes than for forest product. This is especially true of portions which have a reputation as winter resorts, and in time a considerable value may attach to much of this land for such purposes.

Cedar swamp is valued as follows: Stump land, $5 to $10; 35 years' growth, $15 to $200; 50 years' growth, $75 to $400; location and thriftiness both affecting the value so as to cause wide ranges. Heavy cedar swamp has been known to sell as high as $800 per acre. We estimate the average value of all cedar swamp in the State at about $90 per acre, although this valuation is tentative and somewhat uncertain.

Nearly all of the streams of the pine belt are fringed with cedar swamp, in belts varying from a few yards to miles in width

The entire area of cedar swamp is 52,500 acres, and there is besides 85,100 acres of pine and deciduous swamp which contains some cedar.

The following estimate of the total value of the forest of the State is necessarily an approximation only, but may be useful as a guide, and is believed to fairly indicate the value of timber and land taken together:

Kittatinny mountain and valley and the Highlands; 398,000 acres @ $25,	$9,950,000
Red sandstone region; 194,800 acres @ $40,	7,792,000
Clay and marl region; 147,840 acres @ $35,	5,174,400
Pine forest; 1,191,579 acres @ $10,	11,915,790
Cedar swamp; 52,500 acres @ $90,	4,725,000
Pine and deciduous swamp, containing some cedar; 85,100 acres @ $20,	1 702,000
Total,	$41,259,190

The average value for the whole forest, according to this estimate, is $20.60 per acre. In 1890 the census valuation for 8,355 acres of merchantable timber cut off and returned by the mills to census enumerators was $5.60 per thousand feet, board measure, on the stump, and the yield was 4,986 feet, board measure, of merchantable lumber per acre, giving a value per acre, on the stump, of $27.92 for the merchantable lumber. If we add for the value of cordwood and other products, this will give probably above $45 per acre as the value, on the stump, of this timber. If we add for the value of the land, it will bring it to about $55 per acre. This was probably all upwards of 50 years old, and the value thus determined accords sufficiently with our estimates.

The above valuation may be compared with that of the improved land of the State, of almost exactly equal area, as follows: The 2,662,009 acres of land in farms was valued by the census of 1890 at $159,262,840. If we allow for the 662,882 acres of unimproved land included in farms, $30 per acre, we have $19,886,460. Deducting this from the total value of land in farms, as above, we have for the improved land, including fences and buildings, $139,376,380, so that the value per acre is $70 against $20.60 for the forest.

The 1,999,117 acres of improved land yielded, in 1889, products valued at $28,997,349, while the 2,069,819 acres of forest certainly did not yield over one-seventh of this, but the expenditure for labor, fertilizers, tools, buildings, fences, etc., was also much greater for the improved land. Nevertheless the discrepancy in output and value remains sufficient to make it reasonably certain that all land, suitable for cultivation, will be eventually cleared up, and there will be a still further reduction of forest area in southern New Jersey.

RANGE IN SIZES OF STANDING TIMBER.

A detailed examination of northeastern Highlands forests shows that sizes above 24 inches in diameter and 60 feet in height are rare, although the trees of a very few tracts of timber range up to 30 and 35 inches in diameter. The timber generally ranges from 6 up to 12 or 14 inches; there is comparatively little stump or brush land on the Highlands west of Green Pond and Bearfort mountains. East of those mountains, especially along the lower Pequannock and the lower Wanaque rivers, the timber has been more frequently cut, and consequently the younger growth and brush are more prevalent.

On the southwestern Highlands the forests are in small woodlots attached to farms, and also usually cover the slopes which are too steep for cultivation. The sizes here also range up to 24 inches diameter and 60 feet high, but there are a few larger trees.

The larger sizes have been cut out to a great extent, and the ordinary range is from 6 to 16 inches in diameter and from 30 to 45 feet in height.

The timber of Passaic valley does not differ materially from that of the Highlands in size. That of the Watchung mountains is smaller, very little exceeding 12 inches in diameter, and southwest of Summit there is a large proportion under 6 inches in diameter.

On the red sandstone, in Bergen county, more than half the forest area is made up of timber exceeding 6 inches in diameter, and on Palisades mountain fully three-quarters. In general it ranges up to 30 inches diameter and 80 feet in height, and trees of this last size are quite as common as those of 24 inches in diameter and 60 feet in height in the Highlands.

In Union county, trees 24 inches in diameter are about the largest in the forest. Further southwest, all over the red sandstone district of Middlesex, Somerset, Hunterdon and Mercer counties, timber ranging up to 36 inches in diameter is met with and sometimes this is exceeded, 48 inches being occasionally reached. Generally 36 inches is fully as frequent in proportion to the amount of forest acreage as is 24 inches in the Highlands.

The clay and marl district produces as large trees as the red sandstone, but, taken as a whole, the latter will show a larger average yield per acre in standing timber.

In the Pines the range is from the low brush of the "Plains," a view of which accompanies this report, up to the heaviest pine, ranging from 8 to 18 inches in diameter and about 70 feet high, and this original pine may be accompained by deciduous trees up to 22 inches diameter. Timber as large as this is not usual, however, and ordinarily second-growth pine does not much exceed 10 inches in diameter. Owing to the ravages of fires and other causes a very large proportion of the timber is small, stunted and of little value, particularly so as the common pine, at its best, is not a valuable timber.

In the cedar swamps the range is up to about 15 or 16 inches in diameter and 70 feet high, but a diameter of 12 inches is not often exceeded by any considerable number of trees at the present date.

The above notes have no reference to exceptionally large trees, but describe the ordinary run of timber in the forest.

LARGE TREES.

During our surveys, many trees large enough to attract attention during an ordinary inspection of the forest were noted. These notes were not exhaustive, nor was a special search made for large trees, but a list of them will afford an idea of the size of the larger trees of the State. In the Highlands, the large trees were confined almost entirely to the valleys.

Chestnuts.

Locality.	Diameter, in inches.	Height, in feet.	Remarks.
Jenny Jump Mountain,	32	. .	93 years old.
" "	60	. .	70 years old.
Kishpaugh Mine,	36	. .	100 years old.
Vernon,	42 to 60	40 to 60	4 trees.
Roseville (Sussex Co.),	31	. .	63 years old.
West Milford,	42	40	
"	42	60	
"	36	50	
Midvale,	54	50	
Camp Gaw,	66	60	
"	66	50	
"	62	60	
Wortendyke,	48	65	
Ramseys,	60	50	
"	60	45	
"	62	60	
Saddle River,	60	. .	
"	60	. .	
Ridgewood,	60	. .	
Haworth,	84	. .	
"	78	. .	
Arcole,	76	. .	
Overton,	76	. .	
Oradell	63	55	
Paterson,	36	60	
"	60	60	
Palisades Mountain,	30	80	Several about this size.
Bonhamtown,	54 x 90	50	
Stelton,	36	60	Several this size.
Finderne,	30	40	Four chestnuts about this size.
Princeton,	33	55	Near Cedar Grove, on trap.
"	36	55	

Oaks.

Locality.	Diameter, inches.	Height, feet.	Remarks.
Pochuck Mountain,	48	60	
“ “	36	60	
Vernon,	42	50	
“	30	60	
Stockholm,	30	45	
Milton,	36	40	
Upper Longwood,	60	60	
Berkshire Valley,	31	. .	98 years old.
West Milford,	42	40	
“ “	42	45	
“ “	54	70	
Etna (Bergen county),	46	60	
Tea Neck,	40	. .	
“ “	40	. .	
Hillsdale,	28	70	Several in forest about this size.
New Dover (Middlesex county),	48 x 60	50	Spread of branches about 75 feet.
Stelton,	36	60	Several about this size.
Bonhamtown,	54 x 66	60	
Finderne,	52	. .	
“	66	55	Spread of 90 feet.
Franklin Park,	52	50	
Trenton (near Asylum),	48	65	Several about this size.
Lawrenceville,	54 x 66	. .	Spread, 60 feet.
“	51	. .	
Ewingville,	36	70	Several about this size.
“	72	55	
North Branch,	28	. .	250 years old.
Burnt Mills,	36	. .	Several this size.
Readington,	30	. .	190 years old
Flemington,	60	. .	Spread, 50 feet.
“	36	70	Several about this size
Wickecheoke creek.	36	50	
Musconetcong mountain,	30	. .	104 years old.
Pohatcong mountain,	31	. .	100 years old.
Winslow (Camden county),	26	. .	
“ “ “	27	.	
“ “ “	23	. .	
New Lisbon (Burlington county),	30	. .	
“ “ “	19	. .	
“ “ “	17	. .	

Miscellaneous.

Locality.	Kind.	Diameter, inches.	Height, feet.	Remarks.
Pochuck mountain, . .	Maple, ...	36	70	
McAfee, ...	"	30	50	
"	"	30	50	
"	Black walnut,	36	50	
Vernon, ...	Maple, ...	48	60	
"	"	48	50	
"	Black walnut,	36	50	
Oak Ridge, ...	Maple, ...	36	50	
West Milford, ...	"	42	80	
" "	"	48	70	
" "	Elm, ...	30	75	
" "	Hemlock, . .	30	60	
" "	" . .	36	60	
Wanaque, ...	Pine, ...	30	50	
Wyckoff, ...	Whitewood, .	36	80	
Hohokus, ...	Elm, ...	50	80	Spread, 100 feet.
Piscataway, ...	Maple, ...	42	50	
Hillsboro, ...	Wild cherry, .	52	50	
Moore's Station, . . .	Beech, . . .	36	40	Spread, 75 feet.
Somerset, ...	Hickory, . .	42	70	Spread, 40 feet.
Oak Grove, ...	" . .	38	. .	300 years old.
Winslow, ...	Pine, ...	22	. .	
New Lisbon, ...	"	22	.	

In Dismal Swamp, near Metuchen, are trees which will square 6 inches 60 feet from the ground, and a white oak recently cut measured 8 inches in diameter 75 feet from the ground, and another 16 inches in diameter 56 feet from the ground, and a hickory 6 inches in diameter 70 feet from the ground. A tree cut at Burnt Mills, on the North Branch of the Raritan, yielded 1,066 feet, board measure, of lumber.

RELATIVE PRODUCTIVENESS OF TOPOGRAPHIC DIVISIONS.

These notes are roughly an indication of the capability of New Jersey's soils for timber production. So far as may be judged from our notes and observations, the best soils of all of the topographic divisions of the State will produce heavy timber, but there is a difference in the average productiveness of the several sections. The Kittatinny valley, the several small valleys of the Highlands which are not too much covered with glacial detritus, and the red sandstone plain stand first in order, and the pine region the last. Taken as a whole, the red sandstone plain will average highest, the clay and marl region next, the Highlands third, and the Pines fourth and lowest in productiveness. Perhaps original forest in the best of the pines produced as much timber per acre as the average original forest in the Highlands, but that timber was of far less valuable kinds. Certainly in average yield per acre to-day the pine forest is far the lowest in the scale, and even if fully protected from fires the upland would not produce as great a volume of wood per acre as the Highlands forest.

The census of 1890 showed that from 8,355 acres of merchantable timber cut in 1889 in New Jersey the average yield was 4,986 feet, board measure, per acre. The average yield in Pennsylvania was 10,104 feet, board measure, in New York 5,631 feet, and for the South Atlantic States 5,413 to 8,714 feet, board measure, per acre.

Valuation surveys of eleven pieces of heavy original forest scattered all over the red sandstone gave a range of from 5,800 up to 38,140 feet, with an average of 18,300 feet, board measure, per acre, while similar surveys of original pine forest at Winslow and New Lisbon, made by Mr. Pinchot in a chapter of this Report, give from 3,369 up to 10,170 feet, with an average of 6,631 feet per acre. Perhaps at its best the pine may yield 10,000 feet, as against 18,000 feet for the best of the red sandstone forests.

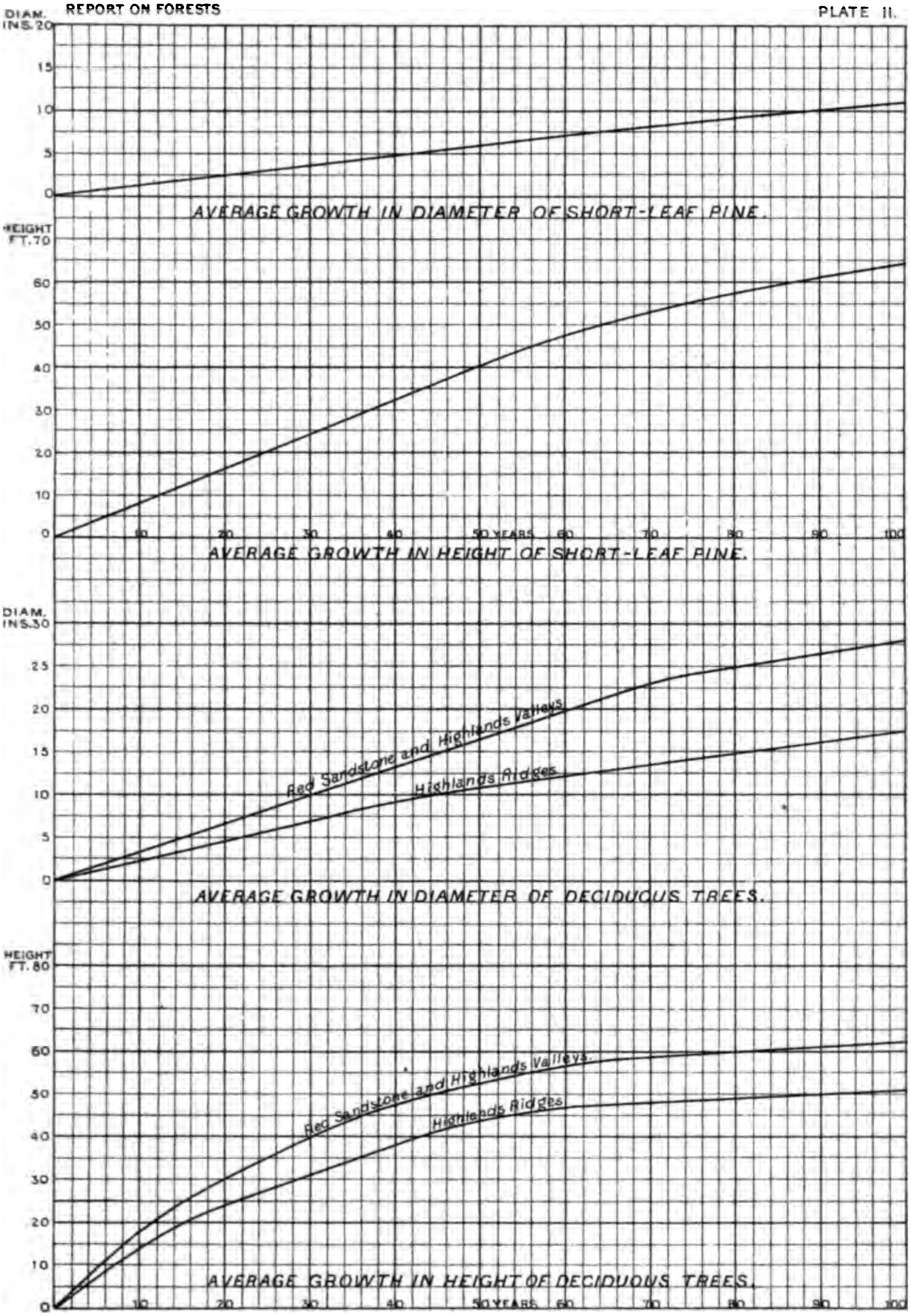
It is interesting to note that the great pineries of the Southern States yield an average of 5,000 feet, board measure, and the best white pine forests of Minnesota a like amount. In estimating the above yield of merchantable lumber, only trees above 10 inches in diameter are taken.

Taking all trees above 6 inches in diameter, the original red sandstone forests give from 1,700 up to 12,400 cubic feet per acre, with an average of 5,247 cubic feet per acre, while the original pine forest shows an average volume of 2,300 cubic feet, the best giving about 2,900 cubic feet.

A very common practice all over the State is to reckon that the forest will produce one cord per acre for each year of its growth; or, more accurately stated, a forest 30 years old will produce 30 cords, and one cord will thereafter be added each year. Several recorded instances in Highlands forest, of about average quality, gave an average yield of eight-tenths of a cord yearly. Perhaps one cord per acre is not too high for the average of all deciduous forest, but the Highlands forests will not exceed eight-tenths of this amount, while the red sandstone forests will exceed it generally for second-growth timber. Second-growth pine does not appear to increase faster than half a cord yearly, even where it is protected from fire, in the light sandy soils of the pine belt.

GROWTH OF TREES.

Having collected a considerable number of measurements of chestnuts and oaks, with some hickories, maples and other trees, I have attempted, in Plate No. II, to represent the approximate curves of average growth of deciduous trees in northern New Jersey. I have found no marked difference in rate of growth of chestnut and oak or other trees. There is a noticeable difference between the rate for the thinner soils, typified by the Highlands plateaus and ridges, and the deeper soils of the red sandstone, Kittatinny valley and the valleys of the Highlands. The growth is consequently represented by separate curves for each. The data are consistent up to about 70 years old, but beyond that there is less certainty, and the variation of growth is large. Thus a chestnut 70 years old was observed having a diameter of 60 inches, and which had one year increased its diameter one inch. Near Camp Tabor a number of trees 35 years old ranged from 24 up to 34 inches in diameter, and from 40 to 50 feet in height. These were remarkable, but a diameter of 36 inches is often reached before the age of 100 years, while a hickory 300 years old measured but 38 inches. The possibilities as to larger size than our average are suggested in the list of large trees previously given. Our curve of diameters would not reach 45 inches in 200 years, or 60 inches in 300 years, yet many of the large trees exceed these measures, and it is not likely that many of the trees are 300 years old. Some trees exceeding 100 years of age measured as follows: 104 years, 30 inches; 118 years, 25



AVERAGE GROWTH IN DIAMETER OF SHORT-LEAF PINE.

AVERAGE GROWTH IN HEIGHT OF SHORT-LEAF PINE.

AVERAGE GROWTH IN DIAMETER OF DECIDUOUS TREES.

AVERAGE GROWTH IN HEIGHT OF DECIDUOUS TREES.

inches; 125 years, 21 inches; 150 years, 20 to 27 inches; 190 years, 30 inches; 250 years, 28 inches, and 300 years, 38 inches in diameter. The curves show the growth in diameter to be at a constant rate up to 65 years on the better soils and about 40 years on the thinner soils, and thereafter it decreases. The rate of growth in height decreases throughout.

It is instructive to note the increase in volume of a tree as shown by the curves. The cubic feet of lumber at various ages figures out as follows:

Age.	Best Soils.	Thin Soils.
20 years,	1.8 cubic feet,	0.7 cubic feet.
40 "	11.4 " "	4.7 " "
60 "	31.2 " "	9.2 " "
80 "	48.0 " "	14.7 " "
100 "	63.4 " "	20.4 " "

This is the gain in volume of the individual tree. Now if there is a constant yearly increase in the yield per acre from 40 to 60 years, such as would be called for by the ordinary rule of one cord per acre annually, it can only be accounted for by the crowding out or dying of many trees. Thus if on the best soil there are 300 trees per acre at 40 years old, the total volume of wood will be 3,420 cubic feet, and if this increases proportionately with the age, at 60 years old it will amount to 5,130 cubic feet, which would require only 164 trees per acre. On the thin soils the decrease would be from 300 trees at 40 years old to 230 trees at 60 years old. Such a rule of yield is therefore more likely to hold good on the poorer soils than on the better soils. The figures show how rapid the gain in merchantable volume is from 40 to 60 years of age, for at the age of 40 years the trees have just reached a merchantable size, and even if we concede that measured as cord-wood the yield per acre thereafter does not rapidly increase, it is clear that the gain in the more valuable merchantable volume is great. If so large a number of the smaller trees are crowded out as is above suggested, this is a strong argument in favor of thinning-out these trees from time to time to be utilized for cordwood, thus leaving the best trees room to grow at a still more rapid rate.

The curves of growth for short-leaf pine are platted from a table given by Mr. Pinchot on page 49 of his paper in the

Appendix to the Report of the State Geologist for 1898. These measurements were made at Winslow, in pine which had been protected from fire. It will be noted that the growth in diameter and height of the short-leaf pine is more uniform than that of the deciduous forest, and is much slower throughout, while the height increases more slowly in early life, but reaches about the same or a greater measurement in 100 years. The rate of growth in height of the deciduous trees, being rapid at first and slower afterward, is analogous to that of the short-leaf pine South, as given in Mr. Pinchot's paper. It is also interesting to note that while the increase in diameter of deciduous trees is much more rapid than that of the short-leaf pine of southern New Jersey, the figures given for trees on Highlands ridges and other thin soils closely approximate the growth in diameter of the southern short-leaf pine. This is made clear in the following tables:

Growth in Diameter. Inches.

Age.	Deciduous. N. J.		White	Short-Leaf Pine.	
Years.	Best Soil.	Thin Soil.	Cedar. N. J.	New Jersey.	South.
20	6.7	4.7	2.2	2.1	. .
30	10.0	7.1	3.7	3.4	7.4
40	13.4	9.3	5.4	4.8	9.3
50	16.7	10.8	7.1	6.0	11.0
60	20.0	12.2	8.6	7.2	12.7
70	23.0	13.7	9.8	8.3	14.5
80	25.0	14.9	10.9	9.2	16.0
90	26.5	16.2	. .	10.2	16.5
100	28.0	17.4	. .	11.0	17.0

Growth in Height. Feet.

Age.	Deciduous. N. J.		White	Pitch	Short-Leaf Pine.	
Years.	Best Soil.	Thin Soil.	Cedar. N. J.	Pine. N. J.	New Jersey.	South
20	30	24	11	16	14	
30	40	31	21	33	24	41
40	47	38	32	45	33	51
50	53	44	40.5	53.5	41	60
60	57	47	48	59.5	47.5	67
70	59	48	54.5	63.5	53	71
80	60	49	60	67.0	57.5	75
90	61	50	. .	. .	61.5	78
100	62	51	. .	. .	64.5	81

While the data for pitch pine are not very full, it is interesting to note that its growth in height approximates to, and after 50 years of age exceeds that of the best deciduous forest.

In comparing the growth of white cedar we must bear in mind the density. The above measurements were made in timber numbering upwards of 1,000 trees per acre, or at least five times as many as the deciduous forest and twelve times as many as in the pine forests. Mr. Pinchot also remarks that where some cedars stood on the edge of a clearing—uncrowded—they showed a rate of growth in diameter just double the average shown in the foregoing table, which would be well above the rate for the short-leaf pine of the Southern States and nearly as great as the rate shown for deciduous timber on the best soil.

INFLUENCE OF MOISTURE.

The large yield and rapid growth of white cedar, which grows in very wet swamps—and the more rapid growth of short-leaf pine in the South, where the rain-fall is more abundant than in New Jersey—leads us to inquire how far this more-rapid growth may be attributed to moisture. It would be interesting to have figures for short-leaf pine in moist localities in southern New Jersey for comparison, although it does not favor wet soils. Water is a most important factor in the growth of the ordinary forest tree, as it is in all plant-growth. From data given in the "Strasburger Botany," I estimate that a thrifty oak forest will, in one growing season, take up into the trees a quantity of water equal to 16 inches of rain-fall, and other independent data enable me to compute that a mixed deciduous forest will take up 19 inches of rain-fall in a season, and a coniferous forest of an equal volume will require even more water.

Some species are not adapted to grow with their roots in standing water, as the white cedar, larch, willow, etc., do, and it may be observed that the presence or absence of free ground-water is sufficient to determine the species in many cases. The chestnut thrives best on the ridges of the Highlands or upon gravelly, well-drained soils in the valleys. It is abundant and reaches its maximum size on the glacial sands and gravels of Bergen county, but is almost unknown on the southwestern red sandstone, where the soil is more compact and more retentive of water. It is also common over the higher gravelly ridges of the clay and marl region, where the soil is good but also well drained. The absence of chestnut on the southwestern red sandstone may be partially due to other soil condition than drainage, however, for the white oak reaches a large size and is prevalent there, as well as in the portion of the State where chestnut flourishes, and it, too, usually prefers well-drained soil.

The species which seems to most persistently seek dry, barren soils is the pitch pine (P. rigida), and it is usually accompanied by scrub oak. They are found together along the rocky crests of Kittatinny mountain and Bearfort, Green Pond and Copperas mountains, as well as all over the highest sandy ground of the pine region of southern New Jersey. The volume of timber per acre is invariably small and its quality inferior in these comparatively sterile regions.

On the other hand, some of the very wet swamps of northern New Jersey are occupied by the larch or tamarack, and nearly all of those of southern New Jersey by the white cedar, almost to the exclusion of all other species.

The swamp white-oak is one of the most valuable of our trees which prefer wet localities. The pin oak and hickory grow on river bottoms where it is less wet, and the soft maple, birch, willow, gum, buttonwood and generally the softer and inferior woods are found in the wettest swamps. The size of the lowland timber of northern New Jersey is almost everywhere greater than that of the upland forest.

The white cedar, growing in the wettest swamps, and the pitch pine and short-leaf pine on the driest uplands of southern New Jersey, each seem naturally perfectly adapted to their environment and may perhaps be legitimately compared. The following figures are from Mr. Pinchot's papers already referred to:

White Cedar.

Locality.	Age, years.	Diameter, inches.	Height, feet.	Volume cu. feet
Whitings, ...	80	9.2	65	8,910
“	79	6.9	60	7,624
New Gretna, ...	66	7.2	60	7,448
Whitings, ...	62	5.4	48	5,868
“	49	4.6	42	5,286

Short-leaf Pine.

Winslow, ...	80	8.9	65	4,483
"	80	8.6	65	4,339
"	55	6.6	45	30 cords.

Pitch Pine.

Tuckerton, ...	50	9.8	47	48 cords.
Whitings, ...	35-60	6.6	47	34 "
Brown's Mills, ...	40	4.4	30	40 "

At the same age the upland pine does not appear to average over sixty per cent. of the yield in volume of the white cedar. It seems probable that this difference is largely due to the abundant supply of water in the cedar swamp.

FOREST FIRES.

While a general survey of the forests of the State fails to indicate that, as a whole, they have deteriorated during the last half century, but really does show a marked improvement, it is none the less true that certain influences have been, and some of them are still, working injury to the forest growth. The chief of these is forest fires, which cause a large annual loss to the owners of the forest, and in some parts of the pines what appears to be a marked and permanent decrease in productiveness.

Mr. Pinchot, after a careful study, estimates that owing to fires the pine forest is now yielding only one-third as much wood as it would yield if protected from fire, and this yield is of a much less valuable kind, being only suitable for cord-wood. These pine-forest fires sometimes burn over 100,000 acres in a single season. In 1885, 128,000 acres were burned over. These figures are sufficient to indicate that if unchecked the entire area would be burned over in less than 25 years. But there are some portions of the forest which have not been burned at all, and a considerable portion is rarely visited by fire. Other parts, usually the inferior timber, are repeatedly burned over.

Mr. Pinchot has given figures which afford means for determining the money-return which would follow effective protection from fire. He shows that pine forest 100 to 200 years old, or say 150 years average age, yields an average of 6,631 board feet per acre, which, if of yellow pine, may be estimated to be worth, as standing timber, $20 per acre. Second-growth seedlings, 80 years old, yield 7,500 board feet, worth about the same amount per acre, the timber being of smaller average size, and second growth from 40 to 60 years old yields about 23 cords per acre. The yearly increment of value may therefore be calculated at 25 cents per acre when the forest is protected from fire. When it is not protected at all, the increment is so small that we may neglect it. If, as suggested by Mr. Pinchot's figures, merely efficient protection from fire will give a return of 25 cents per acre annually for the half of the pine forest which now suffers most severely from fires, or 600,000 acres, it means an aggregate annual return of $150,000. It would therefore seem certain that Mr. Gifford's suggestions as to fire lanes and some well-considered plan of fire wardens would be worth while, if we consider only the direct money-return from the timber.

While the aggregate return is sufficiently attractive and promising, however, the stand-point of the owner, say of 100 acres of pine forest, is necessarily different. We can, at best, only hold out to him a possible annual increment of $25 to his holdings, which can scarcely be convertible into cash by him, and may not be realized by the next generation even, while he is confronted with an absolutely certain annual outlay of $3 or $4 for the cost of protection, in addition to any other taxes to which the property may be subject. The apathy of the present owner of the forest is therefore not unnatural, although we personally believe that if some efficient system of protection can be put into operation the forest will soon profit by an advance in value greater than that due to the wood alone.

There are other strong reasons for protecting the pine forest, which, while they may not appeal strongly to the individual forest owner, certainly do appeal to the people of the State at large. If by successive fires the forest cover should be destroyed, this sandy district will become a terribly forbidding waste of shifting sand, blown hither and thither by the varying winds. Something of this kind may be seen already in many old clearings, notably near Manumuskin creek, in Cumberland county, where the sand is piled in great shifting dunes. The mild-winter climate of the region, which deserves its increasing popularity, will undoubtedly be most unfavorably affected, for it is due in no small measure to the shelter afforded by the pines against the cold west and northwest winds.

In the purely deciduous forest, fires do not gather serious headway, and the timber also resists fire more effectively. The pitch pine and mixed coniferous and deciduous areas on Kittatinny, Bearfort, Green Pond and Copperas Mountains, and in the swamps of the extreme northern Highlands, about Canistear and Wawayanda, suffer considerably, but most of the timber affected is of small value.

FOREST MANAGEMENT.

The coppice chestnut of the State produces the best results when cut at an age of from 40 to 50 years. If not cut, it deteriorates rapidly by rotting at the heart or by becoming shaky. For railroad ties, telephone and telegraph poles or fencing, second-growth chestnut is always preferred, as it is a firmer wood. On the other hand, if cut too young, each succeeding growth becomes weaker and less valuable. Where it has been most frequently cut some areas now need re-planting.

When we consider how much of the Highlands forest is composed of coppice chestnut it becomes immediately apparent that it would be a mistake to reserve any large part of this forest and allow it to stand indefinitely without cutting. The result would soon be serious deterioration and most undesirable conditions in the forest from the decaying coppice wood. It follows that scientific forest management must of necessity go hand-in-hand with any system of forest reservation if such reservation is to at all improve upon present conditions.

We have already pointed out the possibility that the soil may become exhausted by continuous cropping with forest trees. This possibility must be taken into account in forest management. The most serious evils of present management seem to have resulted from too frequent cutting, a practice which has at present almost ceased, the browsing of cattle in the young growth, and neglecting to thin out the growing trees where the stand is too thick. It would seem to be almost possible, with proper management, to obtain all the fuel and other small wood needed in the State by thinning out and pruning, without at all encroaching upon the normal yield of merchantable timber. The young growth nearly always comes up much too thick to allow the choicest of the trees to attain their maximum rate of growth and normal size. Many of the wood-lots attached to the farms of the State now contain fine stands of merchantable timber after having for perhaps a century or more yielded the fuel and fencing needed on the farm. It is significant in this connection that Mr. Pinchot's surveys give a yield of 7,500 feet, board measure, for second-growth pine 80 years old, and only 6,631 board feet for original forest from 100 to 200 years old. We have also much testimony of forest owners indicating a slow gain in volume of wood per acre after 40 years of age is reached, but against this there is plenty of evidence of the rapid growth of individual trees. If merchantable lumber is sought, therefore, the moral would seem to be not to cut thrifty trees until they have attained a diameter of at least 18 inches, but to cut out the larger mature trees, and the small, stunted ones or the inferior species, thus leaving the healthful and valuable trees forty or fifty years old room to grow. Under these improved conditions such trees may easily more than double their volume in 10 years, and quintuple it at the age of 80 years.

It must be confessed, however, that in this State a crop of railroad ties or telegraph and trolley poles may be often cut when the timber is 40 years old to yield a considerably larger return per acre, and, considering the period of growth, a very much larger return annually than can be had by waiting 80 years for a crop of merchantable lumber. Thus, if 10,000 board feet of logs per acre will bring at the saw-mill $12 per thousand, or $120 in all, only 60 poles, bringing $2 each at the nearest railroad station, will yield a like amount per acre and double the annual return, and will much more surely be had from a forest 40 years old than will the merchantable logs at 80 years. Indeed, it ought to be quite as probable that the crop of poles would be double these figures, and the consequent annual return from the forest four times as great from the poles as from the lumber. Certainly, where chestnut can be grown, railroad ties and poles are a profitable product, so profitable that there is little prospect of any serious attempt being made to grow merchantable lumber.

Field Notes of Forest Conditions.

The following notes are the results of detailed examination of the forests of New Jersey made during the progress of our studies. For the purposes of this examination the forest was grouped into the following classes:

1. Brush or stump land, to include no areas intended to be cleared and cultivated.
2. Old clearings formerly cultivated, but now growing up to timber.
3. Young growth, in which class was included all timber less than six inches diameter, the approximate age, size and height being noted.
4. Large timber, including all over six inches in diameter, the diameter and height being noted as before.

Without attempting any strict botanical classification, the varieties of timber have been designated as follows:

1. Deciduous, with the prevailing varieties indicated.
2. Coniferous, classified as pine, cedar, hemlock, etc.
3. Mixed deciduous and coniferous.

Notes were kept of the general character of scattered growth over lands under cultivation, also of the general condition of the forested areas, and of any remarkably large trees, any original forest, planted timber, brush land which seems incapable of producing timber, the succession of growth, &c. Information was also collected as to the value per acre of stump land, of twenty-years or thirty years' growth of timber, and all heavy timber of various kinds. We also took the testimony of reliable persons as to how the amount of timber now standing compares with that of previous periods, and of how the growth on slopes of hills compares with that in the valleys or on the top of plateaus.

It will be noted that the inquiries were of the most practical kind, and it is believed that the information obtained will be of value in reaching an understanding of the actual economic condition of our forested areas. Thus far they have developed the fact that there have been no important changes, either in the limits of cultivated land or in the proportion of forested and cultivated areas, since the topographical surveys were begun in 1877. There have been minor changes, and a few old clearings of small area have been allowed to grow up, the areas thus added to the forests being just about offset by that which has been brought under cultivation, likewise in small scattered parcels.

The topographical maps showed forested lands as distinguished from those under cultivation. They made no attempt to indicate the varieties, size or condition of the timber. There is very little land in the northern part of the State which, if left uncultivated, does not spontaneously produce, in a few years, a fairly good growth of timber; consequently, the land represented as forest on the maps, for which the surveys were completed in 1887, ranges from brush to good timber of from forty to fifty years growth, and for the most part every gradation of growth is represented in due proportion.

Like almost every other physical feature of the State, the forests may be classed broadly into five divisions corresponding with the geological formations, and each of the three northern divisions must be subdivided into glaciated and unglaciated districts. There is a marked difference in the proportion of forest area, and also a less marked difference in the varieties of timber north and south of the terminal moraine line. Consequently we can most conveniently consider the forests by the several topographical divisions adopted and followed in the "Physical Description" of the State, published in 1888. (See also Physical Geography of New Jersey, by R. D. Salisbury.)

NORTHEASTERN HIGHLANDS.

First, on the extreme northwest of this district we have Pochuck mountain, a Highlands region lying detached from the main plateau, like an island, at the eastern side of the great Kittatinny valley. The forests of this region cover about two-thirds of the area, and consist mainly of oak and chestnut, with a considerable amount of hemlock, and some red cedar where old clearings have grown up. A considerable portion of this timber is from 40 to 50 years old, and there are a number of large trees which we shall note later in connection with the forests of the main plateau.

Vernon valley, which separates Pochuck mountain from the main group of the Highlands, is a fertile agricultural district, with a very small amount of forest, but it has a goodly supply of scattering trees which are thrifty and often of large size.

Passing on to the southwest we come to the Alamuche-Pohatcong range,* the glaciated portion of which includes the district lying between the Lehigh and Hudson River railroad on the west, and the valleys of the Walkill and Lubber's run on the east, and extending from Franklin Furnace southwest to the Vienna and Hackettstown road. We find the conditions as follows: From Franklin Furnace southwest to the line of the New York, Susquehanna and Western Railroad, this ridge is known as Pimple Hill. The growth of wood is thin, ranging from 2 to 8 inches in diameter, and consisting mainly of chestnut, oak and red cedar, with a few other coniferous trees scattered throughout the whole district. On the high hill near the railroad and north of Sparta, and also along the ravine southwest of Franklin Furnace, the conifers are quite abundant. The growth, however, is principally chestnut and oak, the best of which is from 6 to 24 inches in diameter, and 30 to 55 feet high, a good proportion of these trees being about 12 inches in diameter. Not much cord-wood is cut in this section, but the best timber is selected and taken out here and there as needed. Between the New York, Susquehanna and Western railroad and the highway from Sparta to Pinkneyville there are very few coniferous trees, chestnut and oak being predominant, and somewhat larger than on the Pimple hills, measuring from 9 to 16 inches in diameter and 30 to 55 feet high. Just northwest of Sparta there is a ridge which has been entirely stripped of timber, but there is no clearing in any of this district for farming purposes, and there does not appear to be much cleared land lapsing back into forest. The flat swamp-land on the Walkill southwest of Sparta has some timber, mostly bordering the stream. There are maples and elms 12 to 24 inches in diameter and 40 to 50 feet high interspersed with a good deal of brush, and near the head of the swamp there are a few good white pines, also a number of hemlocks about the headwaters of the stream. The ridge just west of this swamp is well wooded at the north end, the trees being mostly 10 to 14 inches in diameter, but ranging up to 24 inches. The larger trees have been cut out at the southern end of the ridge. There are red cedars bordering the clearings. Tar Hill ridge in Andover township, just east of the Lehigh and Hudson River railroad, is quite well wooded. A small portion has been cut off within the last five years, more within ten years, but generally the timber runs from 6 to 24 inches in diameter and from 30 to 50 feet high, the larger sizes being not very numerous. There are a good many hemlocks and red cedars and a few white pines. On the ridge line between the Upper Wallkill and the easterly branch of Lubber's run, and stretching from Sparta to Roseville, the timber is small southward as far as the Gaffney mine, most of the large growth having been cut out. In a few spots trees were noted 18 to 24 inches in diameter, but for the most part they are less than 8 inches. On the west slope there are a great many red cedars and a few hemlocks. In the swamp near Gaffney mine, and also the one just southwest along Lubber's run, there are a good many tamaracks. The hills just east of Stag pond are well wooded on the tops, the trees ranging from 6 to 18 inches in diameter, but the steep slope just east of the pond and its outlet is broken and rocky, and is mostly red cedar and hemlock, with a few white pines. There are also hemlocks and a few white pines on the ridge north of Roseville. A tract of 500 acres at Roseville has had all trees 9 inches in diameter and over cut out. An examination of the stumps showed that oak 60 to 70 years old ranged from 18 to 24 inches in diameter; from 40 to 50 years old ranged from 13 to 21 inches, being mostly 13 and 14 inches. An oak stump 89 years old measured 24 inches, and showed that for the first 20 years the growth had been very slow. Chestnut 63 years old measured 31 inches, and hickory 90 years old 19 inches. Generally over this tract from Sparta southwest to the Roseville and Andover highway the timber was in good condition. In a few places it had been cut within 3 years; other tracts within 15 years, but a great many of the trees would average from 12 to 20 inches in diameter. Other portions would average from 8 to 15 inches in diameter and from 40 to 55 feet high, although some of the largest timber seemed to be over 60 feet. While oak and chestnut predominate, there is scattering white pine and hemlock throughout.

---

* The "Western Highlands range" of Prof. Salisbury.

Between the Andover and Roseville highway, the Sussex railroad and Lubber's run there are a few trees 24 inches in diameter, but for the most part they run from 6 to 14 inches, with a height of from 30 to 50 feet. Near Andover, on the road to Roseville, the timber was 10 to 20 inches in diameter, and 50 to 60 feet high.

The portion of this district extending from Sussex railroad southwest to the highway from Hackettstown to Alamuche is known as Alamuche mountain, and is almost a solid forest. In the Kitattinny valley, between the foot of the mountain and the Lehigh and Hudson River railroad, the country is highly cultivated, the scattering patches of timber being composed of small oaks and chestnuts from 4 to 6 inches in diameter and 15 to 35 feet high. In each grove there are a few large trees from 10 to 30 inches in diameter and 40 to 60 feet high, but most of the larger trees have been cut out for timber or other purposes. There are also a good many red cedars. Along the streams and in the swamp near Alamuche elms and maples prevail, the larger ones being 24 inches in diameter and about 50 feet high. There has been a considerable amount of clearing recently in this swamp, which is being ditched and brought under cultivation as a result of the improvement in the drainage of the Pequest valley. Passing along the road from Andover to Alamuche the trees seemed to range from 8 to 20 inches in diameter and about 55 feet high; further along, from 6 to 24 inches in diameter and from 30 to 55 feet high, mixed with a smaller and denser growth. About Tranquillity timber was noted from 10 to 20 inches in diameter and 40 to 50 feet high, and near Alamuche it ranged from 4 to 18 inches and from 20 to 45 feet high. It is somewhat smaller toward the top of the mountain eastward from Alamuche, and there seems to be a preponderance of trees all through the mountains, ranging from 7 to 11 inches in diameter. Trees as large as 20 inches are scarce and scattering, while there is a good deal of young and small growth. There are a few hemlocks on the rocky slope north of Cranberry reservoir, on the end of the mountain north of Alamuche, and near Waterloo, while the swamp north of Waterloo has some tamaracks. South of the road from Alamuche to Waterloo there is a game preserve or deer park, and the wood is chestnut and oak, with some hickory, whitewood, birch, maple and elm. South of the road from Warrenville across the ridge to Saxton Falls, the timber is very short, mostly chestnut and oak on the tops of the hills. On the east slope, where it has not been cut, there is a thrifty growth of chestnut and oak ranging from 6 to 14 inches in diameter. A considerable portion has been cut within 3 years.

Mr. James French, of Waterloo, owns 3,000 acres of timber in this vicinity. Mr. Henry French, his son, reports that they do not cut any cord-wood there now, as they do not find it profitable, not being able to compete with the pine cordwood of South Jersey. They sell a good deal of timber on special orders for various purposes, getting out almost anything, for ship-building or other purposes, which may be required. Their tract does not produce timber quite as fast as they need at present. He claims that they work up everything and waste nothing, and thinks that forests are generally in a better condition now than they were 40 years ago, as the larger mills are not cutting much and cordwood is not profitable, that the demand is for the largest timber, and consequently the younger growth is allowed to mature. They also peel quite a good deal of butternut, hickory, oak and birch bark for their trade.

It is interesting to note that about 20 years ago Mr. French bought a tract of woodland in these mountains which had been cut off a few years before. This tract has not appeared to grow since, and is said to be not much more than brush at present.

Continuing southwest to the road from Hackettstown to Vienna we find that the timber is inferior in quality. On the slope just northwest of Hackettstown the timber has been cut within three years, but on the hill-top it is 6 to 14 inches in diameter and from 30 to 40 feet high of chestnut and oak. The timber through this section is in detached tracts, the larger part of the area being under cultivation. Between Hackettstown and Alamuche the timber does not appear to grow well, or is too closely cut. West of Alamuche pond the ridge has a larger growth of chestnut and oak, mixed with a good deal of red cedar. There are also a few white pines on the western slope of this ridge. Along the highway from Warrenville to Meadville, at the edge of the Pequest meadows, there is some of the finest timber which was observed in this region, of chestnut, oak and hickory, from 10 to 30 inches in diameter and 50 to 60 feet high. One piece of about 50 acres, near the head of the small swamp, has been cut within two years. A good deal of the timber on the end of Cat mountain, west of Petersburgh, has been recently cut; what remains is from 8 to 16 inches in diameter, and from 30 to 50 feet high, but it is scattering and mixed with small growth. At the head of the stream, just northeast of Petersburgh, there are a number of tamarack trees. Agriculturally, this section about holds its own. There is not any important lapsing back of cultivated land into forest, and while the smaller houses are allowed to go into decay, the land continues to be farmed as before. It was noted that the end of the ridge, extending westerly and southwesterly from Alamuche pond to Meadville, is badly washed just north of the latter place near the small mill-pond. The bed-rock seems to lie close to the surface and the soil washes off. Such land should be left in forest, as it must become less and less valuable for agricultural purposes.

The region above described constitutes the glaciated portion of that section of the Highlands which we described as the Alamuche-Pohatcong range in the physical description of the State, Vol. I, 1888.

Continuing westerly, we cross the Pequest meadows, which are not strictly a part of the Highlands, but lie within the district. They contain much heavy timber, all deciduous, and of many varieties, but some of the best has been cut during the building of the Lehigh and Hudson River railroad, and since that time. On Mount Mohepinoke, west of Townsbury, less than half the area is forested. The timber varies from 2 to 14 inches in diameter, and from 15 to 50 feet in height, being generally good timber and containing some large trees, from 14 to 24 inches in diameter and 35 to 60 feet high. The under-growth is quite thick, and there are red cedars near Townsbury on some abandoned pasture and stump land. Near Pequest mines some large sumac was noted, 2 to 4 inches in diameter and 10 to 20 feet in height. On Jenny Jump mountain there has also been some recent cutting of timber about the old silver mine. The best growth is on the main ridge of the mountain, and it includes some hemlock. The timber on the foot of the hills, especially on the limestone, is inferior. A chestnut tree, 70 years old, measured 5 feet in diameter at the stump, but was rotten at the heart. About the foot of the mountain, in the valley, oak, chestnut, cedar, ash and poplar were observed. At Southtown some large sumac was noted, measuring from 2 to 6 inches in diameter and 10 to 25 feet in height. Just north of Shiloh, at the foot of the mountain, there is a locust grove covering about one and one-half acres, the origin of which was not ascertained. Southward from Shiloh chestnut and oak prevail, ranging from 2 to 16 inches in diameter and 10 to 45 feet in height, with some good timber near the Hope and Danville road. Southward from this highway, to where the road crosses to Green's pond, there has been much cutting within 15 years, and the timber is now poor in quality. Just south of Kishpaugh mine a chestnut stump showed 100 rings, and measured 36 inches in diameter. One ring was observed measuring one-half inch in thickness. On the south end of Jenny Jump mountain the timber is quite good, ranging from 6 to 18 inches in diameter, and 25 to 50 feet in height. There has also been some cutting here within 15 years. At the outlet of Green's pond there is a tamarack swamp quite heavily timbered. Generally over this region of Jenny Jump mountain and Mount Mohepinoke the steeper slopes are wooded, but some of the gentler slopes have been cleared and are cultivated without suffering from wash. It is generally the fact that there is little or no evidence of wash where the Highlands ridges are deforested on the slope, although it is true that almost invariably the steeper slopes are well wooded. There is much more wash on the slate ridges, showing that it is largely due to the nature of the soil.

Mr. L. V. Williams, of Danville, speaking of this region, thinks that on an average timber is worth $20 per acre, and most of the mountains have a growth ranging from 12 to 18 inches in diameter, with chestnut predominating, but there is also a good deal of oak, especially rock oak, on the ridges. He thinks the tendency is for chestnut to increase and oak to grow scarcer, because the chestnut sprouts grow more rapidly and crowd out the oak. He considers the growth now much better than it was 30 years ago, as it is allowed to stand longer before cutting. Good poplar is growing scarce. Each succeeding growth of chestnut appears to be thrifty. The growth is better on the south and east sides of the hills, although this is not so noticeable when the soil is good. On the Jenny Jump mountain district there seems to be a deterioration in the cleared lands, but elsewhere they are well kept up.

The timber in the Pequest valley, from Danville to Bridgeville, contains maple, elm, oak, hickory, and a little hemlock and spruce. Mr. Williams, before quoted, says that 15 years ago he cut off a piece of timber, near Townsbury, consisting principally of oak, and since then nothing had grown there but red cedar.

The plateau bounded by Bearfort mountain, the New York line, Vernon valley, and the New York, Susquehanna and Western railroad, has about 80 per cent. of its area in timber, consisting mainly of oak and chestnut, a considerable portion of which is from 35 to 40 years old, and only a few acres older, the remainder being younger, ranging down to 5 or 10 years. The growth from 30 to 40 years old ranges from 6 to 10 inches in diameter, and from 35 to 45 feet in height. The more accessible portion of the timber is said to be cut at 20 years. Timber is believed to grow as rapidly as in earlier years. The only wastefulness apparent in cutting comes from the tendency to cut at too early an age, and this practice seems to be just about at the point of reform, owing to a change in demand for hoop-poles and cord-wood, so that there is likelihood of future improvement. The swamp areas indicated on the topographical maps on this plateau are generally wooded with maple, beech, elm, and occasionally with scattered pines, larches and white cedar. A dense growth of rhododendron makes some of the swamps very dark and almost impenetrable. Forest fires sometimes give trouble, and a large area east of Canistear, near Bearfort mountain, was burned over in 1894. On this same plateau, southwest of the railroad at Stockholm, the condition of the timber is quite similar to what we have already described for the first two or three miles, but farther southwest the timber is older and larger. Chestnut is said to generally succeed all other growth, accompanied by a considerable percentage of oak. Pine is said to have been succeeded by oak and chestnut. The eastern slopes of the hills are thought to produce the best timber, especially near the foot, while the extreme tops also often produce good timber. This is attributed to greater depth of soil.

Pochuck mountain, lying just west of this plateau, does not differ from it materially, excepting that there is more hemlock and a somewhat thriftier growth. It is also not quite so densely wooded. Over the cleared portions the scattered growth is usually oak and chestnut, with some red cedar, maple, black walnut, &c. All these trees are of good size, the cedars from 8 to 12 inches in diameter and 40 feet high, and the other varieties from 12 to 24 inches in diameter and averaging about 45 feet high.

In noting large trees, here as elsewhere, no attempt was made to include them all, the purpose being rather to indicate about what could be seen in passing over the country, and the capacity of the soil to produce good timber. Four chestnuts were noted, ranging from 42 to 60 inches in diameter, and from 40 to 60 feet high, mostly near Stockholm and along the road to Vernon. The following oaks were also seen on Pochuck mountain: One, one-quarter mile west of Sand Hills, 48 inches in diameter and 60 feet high; another, one mile north, 36 inches by 60 feet, the spread of branches being 40 feet. In Vernon, there is one 42 inches in diameter by 50 feet high, and 3 miles north of Stockholm another oak was seen 30 inches in diameter by 45 feet high. An elm, one mile north of Stockholm, measured 30 inches by 50 feet, and another, northwest of Vernon, 30 inches by 60 feet. A maple was seen on Pochuck mountain 36 inches by 70 feet; two, east of McAfee, in the valley, about 30 inches by 50 feet; two, south of Vernon, about half way to Stockholm, about 48 inches in diameter by 50 and 60 feet high. Black walnuts were noted as follows: One, one-half mile east of Vernon, along the Valley road, 36 inches by 50 feet, said to be one of the original forest trees. At McAfee, there is one 66 inches by 85 feet. On the side of the mountain, southeast of McAfee, there is an apple tree measuring 36 inches in diameter by 45 feet high, which is said to be the largest in Sussex county. Two miles southwest of Vernon, on the road to Stockholm, an oak and a walnut have grown together. At the base their combined diameters are 48 inches; above the junction each is about 24 inches in diameter.

The following was obtained as average values of timber near Stockholm: Stump land, $2; 20-years' growth, $7; 30-years' growth, $10; heavy chestnut or mixed oak and chestnut, $80. Heavy oak is said to be extremely scarce, but is quoted at from $60 to $100 per acre. At Vernon, stump land, $2; 20-years' growth, $7; 30-years' growth, $12; heavy chestnut or mixed oak and chestnut, $80. There is said to be very little valuable pine. At McAfee, stump land, $3; 20-years' growth, $7; 30-years' growth, $10; heavy chestnut and oak, $75 to $80. At Canistear, stump land, $3; 20-years' growth, $10; 30-years' growth, $15; heavy chestnut, $60.

We shall next take up the balance of the glaciated portion of the central highland plateau which lies between Longwood and German valleys on the east, and the valleys of the Wallkill, Lubber's run and the Musconetcong on the west. Northeast of the Sparta turnpike, connecting Sparta and Dover, it is very generally forested, probably less than 10 per cent. of the whole being under cultivation. Along the western slope, between Hardistonville and Sparta, the growth is mixed, deciduous and coniferous, the latter being much the larger, from 10 to 20 inches in diameter and 40 feet high. On the top of the mountain, just east of Franklin Furnace, about Two Bridges, the growth is young, but little being even large enough for cordwood, and very little as much as 30 years old. Thence along the top of the mountain to Ogden mines, the timber is mainly deciduous, and from general report, practically all of the timber has been cut once since the period of charcoal forges. About Ogden mines there is some older growth, but all the larger trees are cut out, the stumps averaging 40 years old, and a single one running as high as 53 years. Between Morris pond and the road to Ogden mines the growth is from 2 to 6 inches in diameter and 15 to 20 feet high, and about 12 years old. Between Ogden mines and Hopewell, down to the Sparta and Milton highway, we noted stumps which indicated the growth there to be from 34 to 40 years old. Generally it appeared to be from 4 to 8 inches in diameter and 20 to 30 feet high, but a few trees 16 inches in diameter and 50 feet high were noted. The growth is all deciduous. The north slope of Bowling Green mountain, and westward beyond the Ogden mines railroad, has a growth from 34 to 44 years old; one oak stump was noted 47 years old and 10 inches in diameter. On the top of the ridges hereabout the growth is from 2 to 8 inches in diameter and from 20 to 30 feet high, but where there is more soil the trees are from 4 to 14 inches in diameter and about 40 feet high. Between Morris pond and Hurdtown, west of the railroad, the timber is deciduous, with a few scattering pines, and it is generally small with some stump land, some 5 years' growth. The different tracts ranged from 2 to 5 inches in diameter and 20 feet high, from 6 to 12 inches in diameter and 35 to 45 feet high, from 6 to 24 inches in diameter and 55 feet high, but trees 24 inches in diameter are very scarce. The best wood in this section is along the road from Woodport to Schofield mine, and is from 6 to 15 inches in diameter and 60 feet high, most of the trees being of the larger size, but the portion of this near the railroad is now being cut. The timber on the top of Bowling Green mountain is also good, from 6 to 14 inches in diameter and 40 to 55 feet high, the larger sizes predominating. This has also been cut in places. The west slope of Longwood valley was cut about 12 years ago; there are a few coniferous trees, spruces, pines and red cedar.

West of Woodport, between the head of Lake Hopatcong and the head of Lubber's run, the country is well wooded with oak and chestnut and scattering conifers. About Henderson cove, on the lake, there are scattering white pines and hemlocks. Excepting toward Bear ponds, where it is about 10 years old, the growth ranges from 6 to 24 inches in diameter and 30 to 60 feet high, most of the trees being from 8 to 14 inches, but occasionally one is found 36 inches in diameter. There is exceedingly little cleared land in this tract.

Between Lake Hopatcong and the valley of Lubber's run, from Byram cove to Stanhope, the country is almost entirely wooded. About Bear ponds there is much young growth from 6 to 15 years old, with better timber along the lake about Byram cove and Davis cove, ranging from 2 to 8 inches in diameter and from 20 to 35 feet high. From the River Styx to Brooklyn, it ranges from 6 to 14 inches in diameter, from 30 to 50 feet high, and is entirely deciduous. Along the highway from Roseville to Stanhope reservoir, across the mountain, the timber is still better, while along the Musconetcong river, from Stanhope to Old Andover, it is large, ranging from 10 to 24 inches in diameter and 40 to 60 feet high, with quite a number of hemlocks. There seems to be a general absence of coniferous trees near Lake Hopatcong, but they are much more prevalent toward the valley of Lubber's run. It was noted that, generally, throughout this western portion of the Highlands, there was very little evidence of bad effects from deforestation, even where the slopes are cleared and cultivated they do not seem to be inclined to wash as a rule. This is probably largely due to the nature of the soil. It was also noted that, while many of the small buildings are allowed to go down, the land cleared is as well cultivated as it was 15 years ago, when the topographical survey was made. There is practically no change in the location or extent of the forested areas. There was some exception to this state of things noted in the valley of Lubber's run, throughout which the farm lands seemed to be not so well cultivated, and showed signs of lapsing back into forest. Throughout the hill region chestnut and oak predominate, but in places there is a great deal of hickory. The better timber seems to sell at from $40 to $60 per acre.

Taking next the plateau east of Lake Hopatcong over to Longwood valley, we find, between Hurdtown and Lower Longwood, timber generally from 6 to 12 inches in diameter and 25 to 40 feet high, with some portions smaller. Near the Dover and Sparta turnpike the timber becomes somewhat better, ranging from 6 to 18 inches in diameter and 35 to 50 feet in height. On the end of the ridge east of Woodport, and near the lake, there are several white pines. Following down the turnpike toward Longwood valley, the growth becomes smaller again. Along the western slope of Longwood valley, from Lower Longwood toward Berkshire valley, a fire has extended about 1½ miles through young growth from 2 to 4 inches in diameter, all of which is dead. Further southwest, the timber ranges from 4 to 12 inches in diameter and 25 to 40 feet high. There is some coniferous growth, mainly spruce and hemlock. Continuing southwest from Berkshire valley, on the road to Davenport mine, it was noticed that some large oaks had been cut, ranging from 94 to 99 years old, and from 21 to 31 inches in diameter. From Davenport mine to Hopatcong, the timber ranges generally from 6 to 24 inches in diameter and 25 to 60 feet high. At one place all trees large enough for railroad ties had been taken out. Southwest of Lake Hopatcong branch of the Central railroad, over to the Delaware, Lackawanna and Western railroad, the timber is generally from 6 to 12 inches in diameter and 20 to 60 feet high, but there is some smaller growth only about 2 inches in diameter.

The age and diameter of a number of stumps in this region east of Lake Hopatcong were recorded, and become an index of the rate of growth of the timber. We give following, first the age, and then the diameter for different kinds of timber: Chestnut, 93 years, 32 inches; 89 years, 13 inches; 60 years, 14 inches; 43 years, 12 inches; 33 years, 9 inches. Oak, 99 years, 24 inches; 98 years, 31 inches and 21 inches; 95 years, 24 inches; 94 years, 27 inches and 24 inches; 79 years, 14 inches; 78 years, 13 inches; 37 years, 9 inches; 33 years, 9, 11 and 14 inches; 32 years, 13½ inches; 30 years, 13 inches. Maple, 33 years, 14 inches. It was noted that several trees from 74 to 89 years old had apparently grown rapidly and uniformly until 30 years old, then very slowly for ten years, but after that more rapidly again.

There is a general improvement in the cleared land and buildings in the neighborhood of the line of the Ogden Mine railroad. This is, no doubt, partly due to better railroad facilities since this railroad was connected with the Central Railroad of New Jersey and partly to the recent extensive operations at Ogden mine. Notwithstanding this improvement, however, little land has been cleared for cultivation, but the old clearings are better cultivated and cared for. Along the east shore of Lake Hopatcong there has been a considerable development as a summer resort, but this has not been attended by much clearing-off of forests, the trees being preserved so far as possible.

From interviews with Mr. Titman, of Sparta, and others it was learned that the greatest damage to forests in this vicinity comes from fires and cattle, the latter browsing off the young growth, or breaking it down. It is said that a fire which causes no great apparent damage at the time will cause the timber later on to decay at the heart. There seems to be very little wood in this district over 40 years old taken as a forest, although there are scattering trees very much older. As a rule the timber grows slower on the west and north slopes of the hills. The growth also varies with the character of the soil, and where the latter is very thin in certain instances a 40-years' growth has not attained sufficient size to be of any use, even for cord-wood. Mr. Decker, who formerly ran a forge at Sparta, says that he shut his works down in 1865. He also says that when forges were running throughout this section wood was often cut when 15 years old for coaling. Sprouts now come up quickly, and appear to be thrifty, but he thinks that if fires continue they will cause a deterioration in the forests. He also says that hemlock is usually left standing when the other timber is cut off, as it does not pay to get it out if at all inaccessible. This fact accounts for the larger size of most of the coniferous growth standing throughout this part of the State.

On Bearfort mountain timber has suffered much from fires. In 1882, during the prosecution of the topographic survey of that section, a fire ran over a large area south of the road from Greenwood lake to Wawayanda, and this fire did injury from which the forests have not yet recovered. A fire in 1891 ran over most of the mountain tops from the State line to Cedar lake. The timber is generally, both on account of these fires and the thinness or entire absence of soil over much of the mountain, scattering and of little value on the high ridges, but owing to its inaccessibility there has always remained a considerable amount of original forest, and in 1882 there was some quite heavy timber in the ravines, notably in the one heading at the westernmost of the two small ponds near the State line. This ravine was then heavily timbered, and travel through it was difficult, owing to fallen tree-trunks. It was a good example of virgin forest. But, generally speaking, over the mountain tops the growth is scattering and inferior, which condition has been much aggravated by the recent fires referred to. There is a good deal of the common pine and some hemlock scattered over the mountain. The best timber is along the eastern slope, although this is all second growth; but the present growth is from 30 to 40 years, 8 to 10 inches in diameter, and 40 to 45 feet high. It is mainly oak and chestnut and scattering pine and hemlock.

Green Pond and Copperas mountains are mainly covered with a 40-years' growth of oak and chestnut, rather sparse and poor on the top and eastern face, where the soil is thin, but fairly good on the western slopes, being there generally from 8 to 12 inches in diameter and 35 to 45 feet high. As on Bearfort mountain, there is a sprinkling of common pine. Some lots, aggregating perhaps 150 acres, have been cut off within from 10 to 15 years, but the remainder, if recently cut at all, has been only thinned out.

The west slope of Green Pond mountain has deciduous and coniferous trees in nearly equal number, consisting mainly of oak and chestnut from 4 to 10 inches in diameter and 30 feet high, or spruce and hemlock 6 to 12 inches in diameter and 50 feet high. The east side of the mountain has timber of the same general character, while the flat top has a scattering growth of common pines, interspersed with scrub-oak (*Q. ilicifolia*). It is noticeable that the coniferous growth disappears on this mountain, south of the highway from Middle Forge to Berkshire valley, and the deciduous growth runs from 4 to 14 inches in diameter and 20 to 45 feet high, deteriorating southwest, and ending in brush and scrub oak in the district north of Kenvil. Scrub oak prevails over the entire Bearfort and Green Pond mountain district, especially on the top of these ridges and on the sands which accompany this formation west of Clinton and on Succasunny plains.

The valley at Milton and Oak Ridge contains most of the cultivated land of this region, but about one-third of its area is in timber, mainly oak and chestnut, of all ages, from 15 to 60 years, with a little pine along the road south of Clinton, and some maple and other soft woods in the low grounds. It is noticeable that all the principal slopes about this valley, and generally on the upper Pequannock water-shed, are well timbered. The valley has a considerable number of scattered trees over its cultivated portion, mostly from 8 to 12 inches in diameter and

40 to 50 feet high. The large trees noted were a black walnut, three-quarters of a mile west of Milton, 30 inches by 50 feet; a red oak, one-quarter of a mile north of the same place, 36 inches by 40 feet, and another, near Upper Longwood, 60 inches by 60 feet. From Petersburg to Upper Longwood, along the road, there are from 20 to 30 oaks and maples, ranging from 12 to 24 inches in diameter and averaging 45 feet high. A maple east of Oak Ridge measures 36 inches in diameter by 50 feet high.

The portion of the Highlands lying between the valley running from Greenwood lake to Newfoundland, and Wanaque and Passaic valleys, was designated the Passaic range in the "Physical Description." A portion of this, north of Pequannock river, has 75 per cent. of its area in forest, the central belt of the range being almost unbroken by clearings. In the northern part there is a considerable amount of oak and chestnut, from 30 to 40 years old, including, perhaps, one-quarter of the whole region, while another large tract appears to exceed 45 years in age, all the more accessible portions near Wanaque valley and the Pequannock being young growth of all ages, from 3 to 5 years and upward, with very little stump land and no new clearing. It is evident that the practice of cutting at 20 years or younger has prevailed along the lower Pequannock, and it would appear that the forest has suffered injury in consequence. This young timber seems to have been mainly cut for charcoal, fire-wood, hoop-poles, &c. While the timber is mostly oak and chestnut, there is some pine and hemlock between Macopin and West Milford, also red cedar in old pastures, and some white cedar south of Greenwood lake. The only portion of consequence which seems to have suffered from fire is an area of perhaps 150 acres along the Greenwood Lake railroad, just east of the lake. Most of the eastern part of this section is owned by Cooper & Hewitt, being a part of the Ringwood tract, and the forests of this part seem to be steadily improving. There is some new cutting about Hewitt, two or three hundred acres of stump and brush land being noted, and also some considerable areas of young growth of all ages.

Continuing along the Passaic range, southwesterly from the Pequannock river to the moraine line at Denville and Dover, chestnut and oak still prevail, with some hickory, and many other kinds of timber distributed throughout. For the most part, it is from 30 to 40 years old, and some scattering parcels, much younger, between Charlottesburg and Marcella, and also between Bloomingdale and Brook valley. This younger portion is considerably mixed with cedar, white birch, &c. There is very little brush or stump land to be seen, and very little timber less than 10 years old. A tract of several thousand acres is now held as a private preserve about Stickle pond, and its forests are likely to be cared for.

The clearings in this district are almost entirely confined to the valleys of Green Pond brook, Beach Glen, Stony brook and the Rockaway river. The high lands are almost entirely covered with forest, the area of which amounts to some 75 per cent. of the whole district. The cleared portions are almost entirely grass lands. The population is decreasing, but there does not appear to be any considerable amount of cleared land which shows signs of lapsing back into forest. Between Rockaway and Mount Hope the timber is oak and chestnut, ranging from 4 to 24 inches in diameter. Between Mount Hope, Hibernia and Denmark the timber ranges from 35 to 50 years old, and cutting appears to be more by culling out the best trees than by clearing off the entire tract, the smaller growth being preserved. West of Rockaway there is thrifty timber, from 8 to 12 inches in diameter, and 40 to 60 feet high, said to be about 60 years old. The timber continues to be excellent, to and about Mount Pleasant mine. About Baker and Richards mines it is apparently as old, but the best has been culled out. Still, it continues to be fair on over to the valley of Green Pond brook. On the mountains, between Rockaway and Hibernia, the timber ranges from about 40 years old, near Beach Glen valley, to 60 years old further west. Some portions have been recently cut, and some are from 10 to 20 years old. But generally the range is from 6 to 20 inches in diameter and from 30 to 60 feet in height. It is mainly oak and chestnut, with a few white pines and other conifers on the top and the more rocky slopes. Between Beach Glen and Meriden, it ranges from 12 to 34 inches in diameter and 50 to 60 feet in height, with a few coniferous trees as before. South and west of Split Rock, the oak and chestnut range from 7 to 35 inches in diameter and 30 to 45 feet in height. It is said that the last cutting about Split Rock for the use of the furnace was some 30 years ago. Further toward Marcella, oak and hickory were noted 10 inches in diameter and 55 feet high, while along the Marcella and Hibernia road the oldest timber is 45 years old, but there has been some recent cutting, and there are some tracts of younger timber.

From Beach Glen, eastward to the Morris canal, the country is well known by Mr. W. K. Clarke, of Rockaway. He says the last cutting for iron furnaces and forges in this district was done 40 years ago, although a trifling amount has been done since. He believes that after the forests here are cut two or three times more the growth will become stunted and worthless, and there will be a necessity for re-seeding. He mentions a 10-acre tract on his property where, in 1838, his father raised a crop of buckwheat. It was then abandoned and oak and chestnut came up. The timber was cut off in 1866, the 10 acres yielding 200 cords of wood. In 1883 it was cut again, yielding from 12 to 15 cords per acre, and now, in 1895, the growth averages 4 inches in diameter and 25 feet high. He thinks the best growth is on the east and south slopes of the hills.

The district which we are describing has generally a growth of from 4 to 16 inches in diameter and 35 to 45 feet high. There are a few coniferous trees, principally white pine, the largest of which was 2 feet in diameter and 60 feet high, and about this tree there were a great many small pines, some 20 feet high, apparently sprung from the seed of the large tree.

North and northeast of Boonton, the mountains appear to have been cut off from 30 to 50 years ago, and are now beginning to yield good timber again. Some of the cleared land in this vicinity begins to grow up with red cedar. About Taylorville, it is said that the timber was cut about 30 years ago for the use of the forges. Mr. Ezekiel Earle, of Lyonsville, furnished the following interesting facts as to this region: Last winter he cut a tract on the hill north of Dixon's pond, the timber of which was 60 years old and which yielded 50 cords per acre. He has some chestnut and oak timber which he has trimmed out and taken care of, and he believes it will yield one-third more wood per acre than other wood of the same kind and similarly located, which has been allowed to grow up in the usual way. His experience is that wood will usually yield one cord per acre for each year that it has been growing. He complains that the timber rots more at the heart now than formerly, and says this applies only to that which has sprouted up from the stump. The seedling trees are much thriftier and straighter than the sprouts. Just east of his home he has a tract of chestnut which has fine timber. The trees are about 45 years old, from 8 to 18 inches in diameter and 40 to 50 feet high. He says the seedling trees in this growth can be picked out with no difficulty. He says the continued cutting and lack of care is injuring the growth from the stump, and believes that the timber will deteriorate from this cause. He mentions a tract which was cut by his father, and which he believes was original forest. Since then it has been cut once more, about 20 years ago, and has never been more than brush since that cutting. He also stated that Andrew Cobb, who owned the forges at Split Rock, used to say that wood was most profitable for coaling when cut every 20 years. The opinion is general hereabout, as elsewhere in the northern part of the State, that the timber is better cut at from 30 to 35 years old than at 50 years, being sounder,

Mr. C. S. Dickerson, of Denville, who has much experience, furnishes the following facts: He is now cutting a tract of 100 acres, for which he paid $50 per acre, including timber and land, the timber being about 60 years old. So far as the young growth is concerned, he thinks it makes no difference whether timber is cut in February or August. He believes the forests in this section are now in better condition than they were 25 or 30 years ago, as they were then cut much younger, owing to the demand of forges, railroads, lime-kilns, &c., and later the hoop-pole industry. He says the second growth of timber is stronger, thriftier and thicker than the original, and each succeeding growth appears to improve. Timber ought to be cut at from 30 to 40 years old, as after that it begins to rot at the heart, and the older stumps do not send out so many or as thrifty sprouts as the younger. He says, also, that cord-wood costs 60 cents to cut, $1.00 for cartage, $1.50 for freight, and, allowing 15 cents for waste, this makes the total $3.25, whereas the market price ranges from $3.00 to $4.00 per cord.

Near Taylorville, some wood 12 years old was recently cut, and the larger trees were decayed at the heart. It is also stated that timber growing rather thin on the ground is better in quality than where it stands too close together, and that it should be trimmed out when about three years old, leaving the healthier sprouts to grow. The general trend of opinion seems to be that the rotting at the heart indicates the necessity of re-seeding.

On this northeastern portion of the Highlands all of the steeper slopes are well forested, excepting a few which are rocky and will not support any growth. The cleared land is almost entirely confined to the bottoms of the valleys, which are usually rather flat. The cleared portions are not highly cultivated, consisting largely of grass land. The water-sheds of the Ramapo, Wanaque, Pequannock and Rockaway lie almost entirely upon this glaciated Highland district, and to this fact is due their peculiar excellence as sources of water-supply for our cities. The foregoing description gives as good an idea of the forest conditions of these water-sheds as could be given by a separate description for each stream.

In Wanaque valley, although the timber is more interspersed with clearings, it does not differ from that already described, excepting that there is more red cedar, which is probably due to the fact that the land has at some time been cleared.

Ramapo mountain is practically an unbroken forest, mainly oak and chestnut. The main ridge, from Negro pond south to the highway crossing from Midvale, is covered with a good growth of perhaps 30 to 40 years old, and most of the flatter portions of the mountain are likewise well timbered. Perhaps one-third to one-half of the slopes are not so well timbered, owing to thinness of soil. The southern end of the mountain is mostly covered with quite young timber and brush, and the timber on most of the more accessible parts has been cut within 20 years.

Generally, the Passaic range of the Highlands and Ramapo mountain are more lightly wooded, and the timber has been more severely cut during the last 20 years than on the Central Highland plateau westward. The proportion of forested area to the whole is about the same. In this part of the Highlands it is thought, generally, that the timber grows as vigorously as in former years, and it is asserted that a 30-years' growth will yield as much wood per acre as the original forest. Some of the best timber here is on the slopes, but, on the other hand, more slopes have thin soil, and there are more bare-rock ledges than on the central plateau, and these have only a stunted growth or none, but they do not exceed one-third of the entire slope area. Flat hill-tops and ravines are well timbered as a rule, although some ridges are quite bare of soil on the top, and the forest is correspondingly poor.

The larger trees noted were two hemlocks, one mile southwest of West Milford, which measured 30 and 36 inches in diameter and about 60 feet high; a red oak at the same place measured 42 inches by 40 feet; an oak one mile north measured 54 inches by 70 feet, and another, one and one-quarter miles north, 42 inches by 45 feet, being a very beautiful tree. Near the same place we observed two chestnuts 42 inches in diameter and 40 and 60 feet high; a maple 42 inches by 80 feet; another, in a swamp, 48 inches by 70 feet; an elm 30 inches by 75 feet, with a beautiful spread of weeping branches. A chestnut near by measured 36 inches by 50 feet, and one at Midvale, 54 inches by 50 feet; a pine at Wanaque measured 30 inches by 50 feet. No very large trees were observed on the high part of the Passaic range.

Not much reliable data could be had as to values. In the vicinity of Greenwood lake estimates ranged about as follows: Stump land, $5; 20-years' growth, $20; 30-years' growth, $30. At Midvale, stump land, $5; 20-years' growth, $10 to $20; 30-years' growth, $15 to $25; large oak and chestnut, $60 to $80 per acre.

We have noticed that a large amount of Highlands forest ranges from 30 to 40 years old, and only a very small amount exceeds 45 years. All recent cutting also seems to have been of timber about 30 years old or younger. It would appear that much of the forest now standing, or which has been cut in recent years, dates from about 1850. Up to about that date there was a very large consumption of timber for charcoal to supply forges and furnaces, as well as for other kinds of fuel. Recently the cutting of timber less than 20 years old appears to have been somewhat checked. Most of this young timber was cut for charcoal, fuel and hoop-poles. The reason for this check is mainly to be found in the lessened demand or lower prices for these products. The evidence which we have collected seems to indicate that the best results are obtained by cutting at an age of 30 or 35 years. Chestnut, particularly, does not grow so thriftily after this age. A potent factor in checking this cutting of young timber is the tendency now prevailing to acquire large holdings of these northern Highlands. This movement is rapidly under way, and will undoubtedly result in a marked improvement in the condition of the forests during the next 20 years. At Wawayanda lake one owner holds 3,000 acres, and on Bearfort mountain an iron company holds 2,000 acres. At Cedar lake a club holds a large tract as a game preserve. At Ringwood the property of Cooper & Hewitt embraces a large extent of territory. At Stickle pond a private owner has acquired an extensive preserve. Thus private enterprise seems to promise the solution of the forest question in this portion of the State. As most of this land is entirely unfit for cultivation, and should always remain in forest in order to maintain the steady flow of the streams, as well as for other economic reasons, not to speak of the æsthetic, it is a matter for congratulation that such a movement has set in.

FORESTS OF THE SOUTHWESTERN HIGHLANDS.

The line of the terminal moraine, which subdivides the Highlands, crosses from Denville through Dover, Drakesville, the north end of Budd's lake, a point about one mile north of Hackettstown, through Townsbury to the Delaware at Belvidere. The unglaciated portion southwest of the moraine is, as we remarked, much better adapted to agriculture, so that generally speaking the Archæan plateaus and ridges have fully half their surfaces cleared and under cultivation, while the rather broad intervening valleys, which are on the slate and limestone, are almost entirely deforested and under a high state of cultivation.

Beginning at the northwest side as before, we have first the upper Pohatcong mountain lying between the Musconetcong and Pequest valleys. We have previously considered the glaciated portion northwest of the Hackettstown and Vienna highway. Southwestward the mountain is about half forested, the slopes especially being well covered, while the head of Pohatcong valley is deforested. The slope of the mountain, toward Musconetcong valley, is followed by the Morris canal, to which fact may be due the recent cutting which probably includes 60 per cent. of the timber, within 15 years, and much of this has been cut within 5 years. The better-growth standing ranges from 8 to 20 inches in diameter and 30 to 50 feet high. This larger growth prevails over the top of the mountain, where there has been much less cutting. On Furnace mountain, which includes the portion west of the head of Pohatcong valley, the timber ranges from 6 to 24 inches in diameter and 25 to 55 feet in height. Here, also, there has been some recent cutting. The timber is principally chestnut, with a good deal of oak, but we also find maple, birch, beech, poplar, ash, butternut, &c. There is no washing noticeable on the mountain slope, but there is some in Pohatcong valley, especially in the peach orchards and other areas which are not kept in grass or grain.

Just southwest is Scott's mountain, which includes some 40 square miles of plateau, surrounded by deforested valleys of slate and limestone. About one-half of the surface of the mountain is forested, including all the steeper slopes. North of the highway, from Oxford Furnace to Belvidere, the growth is deciduous; oak, chestnut and hickory, with the usual scattering birch, beech, maple, elm, poplar and ash. The best timber is from 8 to 24 inches in diameter and 30 to 55 feet in height, which includes about three-quarters of the whole, the remaining one-quarter having been cut within 10 years. There is a little hemlock near Oxford church. The southeast slope of Scott's mountain, which is also followed by the Morris canal, contains timber from 6 to 18 inches in diameter and 25 to 45 feet high, some of which has been cut within 15 years. On the western slope, toward the Delaware, there has also been some cutting, and in general the best timber is on the top of the plateau, ranging from 8 to 20 inches in diameter and 25 to 50 feet high, mainly of chestnut, oak and hickory, with the other varieties previously mentioned. There is a little cutting, but less than on the slopes. Such slopes as are cleared show no evidence of washing. The most accessible clearings are generally well cultivated. Those less easily reached show a few signs of deterioration.

The valley of the Delaware, westward, is almost entirely deforested, but the few scattered clumps of timber are good. The bluff along the river contains considerable hemlock.

The Pohatcong valley, eastward, including the broad stretch of level country at the south end of Scott's mountain, reaching over to the Delaware river, is entirely deforested, there being a lack even of scattering trees, which makes this territory seem more bare than any other in Northern New Jersey. What little timber there is is confined to the bluff along the Delaware, and consists of a few larger trees from 10 to 13 inches in diameter and 30 to 45 feet in height, interspersed with a good deal of brush. We find here hickory, butternut, beech, oak, elm, birch and a little chestnut and hemlock.

Pohatcong mountain is a narrow ridge extending from Washington southwest to the Delaware river. It has some timber along its slopes, mainly oak, hickory and chestnut, with the other varieties which we have previously named interspersed, and also some clumps of common pine (*P. rigida*) north of Asbury. The north end of the ridge has a medium growth from 4 to 6 inches in diameter, and some of the pasture is growing up to red cedar. A 50-acre lot was noticed on the northwest slope which has been cut within 7 years, and which shows almost no new growth since. The timber seems to have been principally oak. The timber is better as we proceed towards Bloomsbury, ranging from 10 to 30 inches in diameter and 30 to 55 feet in height, but the tracts are small. The best has been, or is now being cut. Just southwest of the Lehigh Valley railroad there is a piece of chestnut, oak and hickory which is better, ranging from 6 to 14 inches in diameter and 25 to 45 feet high. Thence to the Delaware it ranges from 8 to 24 inches in diameter and 30 to 50 feet high, but nearly all has been cut within 10 years, and the best of the remaining is now being cut out. On the ridge near Bloomsbury, oak stumps were noted as follows: 150 years old, 28 inches in diameter; 125 years old, from 21 to 29 inches, and 118 years, 25 inches.

The Musconetcong valley, southwestward from the crossing of the moraine, is generally deforested, but not quite so bare of timber as the Pohatcong valley previously described. The underlying rock of the valley is either slate or limestone, and its surface is highly cultivated. The slopes in the valley show considerable erosion from water, and it would seem that the steeper ones might well be reforested, but, as a whole the country is too fertile to be kept in forest.

Schooley's mountain is crossed by the moraine from Drakesville by the north end of Budd's lake to a point about one mile north of Hackettstown, and this northern drift-covered portion presents a marked contrast to that south of the moraine. It is not only more generally forested but its clearings are neglected, buildings and fences are falling down, and it is deteriorating into a wilderness, whereas, just southwest the clearings are in a high state of cultivation. The timber over this drift-covered area is generally from 6 to 12 inches in diameter, with some better, ranging from 8 to 24 inches in diameter and 30 to 55 feet high, but there is also a considerable proportion of small and inferior growth. There appears to have been a good deal of cutting done 10 or 15 years ago, but not so much recently. The timber is mainly chestnut and oak, but includes a wide range of other varieties. In the swamp west of Budd's lake there are a few tamaracks.

Southwest of the moraine line about 50 per cent. of the surface of the mountain, including the more level portions, is cleared and well cultivated. North of Drakestown the timber ranges from 6 to 16 inches in diameter and 30 to 50 feet high, and from Drakestown to Schooley's Mountain springs, from 6 to 24 inches in diameter and 20 to 55 feet high, but about half of this has been cut within 10 years, although there remains some very good timber. Around Mount Olive the growth varies from 8 to 20 inches in diameter and 30 to 55 feet in height, but there is some smaller growth interspersed. Along the east face of the mountain it runs from about 6 to 14 inches in diameter and 25 to 45 feet high, and there is a little cutting at present, while considerable has been cut from 5 to 10 years ago. There is not a great deal left here which is large enough for profitable cutting. Along the western slope, from Beattystown to Pennville, the timber is good, ranging from 6 to 16 inches in diameter and 30 to 55 feet high, some of which has been, and is now being cut. It is principally chestnut and oak, mixed with other deciduous trees. From Pennville to Changewater the growth is quite good, and about the same size as above, but from Changewater to Junction it is light, and ranges mostly from 6 to 18 inches in diameter and 30 to 45 feet in height, with a few larger trees. This slope of the mountain has washed considerably in places, and especially where there are peach orchards, the wash being much less when kept in grass. Taking this southern part of the mountain, from Schooley's Mountain postoffice to the New Jersey Central railroad, the cutting within 5 years has been very severe, and all the heavier timber is being rapidly taken out. This is more the case than on any other part of the Highlands. Along the south branch of the Raritan all the old timber is cut, and when the lots now being cut are taken off there will be nothing left but timber too young to be of any use. The farms in this section appear to be well kept up. Near Pleasant Grove an oak stump was noted, showing 104 rings, which was 30 inches in diameter. The timber being cut on these southwestern Highlands at present is mostly worked up by steam-mills into merchantable lumber of all kinds, including almost everything for which a ready sale can be found. Practically none of the area being now cut off is intended to be cultivated, but it will be allowed to grow up again in forest.

Musconetcong mountain is next, southwest. Along its western face, from Junction to West End, the average timber ranges from 4 to 8 inches in diameter, and 25 to 45 feet high, of which a good deal has been cut within 10 years, and some quite recently. Some of this recent cutting seems to be followed by a poor and stunted growth, possibly due to the browsing of cattle. Around Pattenburg the chestnut and oak range from 6 to 10 inches in diameter, and 30 to 50 feet high, and on the eastern slope, thence to the Central railroad, the timber is small. The best of this region is on the hills, near Glen Gardner. It is generally oak and chestnut and other deciduous trees intermingled. The result of interviews in this region indicate that, in the first place, the timber was largely cut and coaled for the use of forges and furnaces, and then, after the Central railroad was built, there was a good demand for timber, and the forests were cut off, since which time there has been a lessened demand. The lots now being cut are those which escaped in the period following the completion of the Central railroad. It is said that chestnut grows faster than oak, although there was no complaint of deterioration of chestnut hereabout, after reaching 30 years of age. There is no erosion of the slopes here, and the clearings appear to be well cultivated. Between the Lehigh Valley railroad and the road from Little York to Bloomsbury, the timber is mainly chestnut, oak and hickory, ranging, in different parts, from 4 to 8 inches in diameter, and 20 to 30 feet in height, up to 18 inches in diameter, and 30 to 50 feet in height. Quite a good deal has been recently cut and a considerable area is brush. Along the Musconetcong valley slopes, above Warren paper mills, there are a few hemlocks; and on the same slope, near the West End mines, the timber ranges from 10 to 24 inches in diameter and 40 to 55 feet high. Further southwest the timber on this mountain varies a good deal, the different wood-lots having been cut at widely different periods. Near Gravel hill an oak stump was noted 100 years old and averaging 32 inches in diameter. Mr. D. Harrison, of Bloomsbury, mentions a lot of 20 acres on this mountain which was cut about 12 years ago and which has grown very little since, being now only 10 or 12 feet high, although all around it the growth is good. In general, the timber grows well and quickly. Chestnut usually comes up after cutting off, and he thinks the wood grows as well as ever it did, and that the wood is now better than it was formerly, that is, it is more durable. He mentions a young chestnut pole which was cut 80 years ago and has been in use ever since, being still well preserved.

On Succasunna Plains we find a good deal of scrub-oak, especially just northeast of Flanders, about the sand-pits and eastward of the Morris canal to the northeast of Kenville. This occurs on a sand belonging to the Green Pond mountain rocks, and it is said that this scrub-oak has been the same for a long time. It was noticed that where these scrub-oak lands had been cleared they appeared to raise good crops. Generally there is more timber over the plains than on the other valleys of this portion of the Highlands. Quite a good many white pines were noticed near Flanders, with some young pine, and a few hemlocks. Along the south side of the road from Flanders to Succasunna the timber ranges from 10 to 15 inches in diameter and

30 to 50 feet high. In some abandoned clearings common pine is coming up. There is some tamarack in the swamp south of Drakesville, and it is also found in the swamp on Black river from Horton station to Succasunna.

German valley is generally deforested, especially from Naughright down to Califon.

On the long, narrow ridge at the southeast side of German valley, and running from Succasunna plains to Califon, there is a considerable amount of timber on the northwest slope, mainly chestnut and oak, ranging from 4 to 18 inches in diameter and 20 to 50 feet high, and it appears to be generally attached to farms and utilized in connection therewith.

Taking now the extension of the Passaic range southwest from Dover and Denville, we find generally about one-half of the country in timber, the greatest amount of cleared land being about Mendham and on the Upper Whippany, including Morris Plains. Along the west face of the plateau from Port Oram to Ironia, timber is from 6 to 12 inches in diameter and 30 to 45 feet high, while south of Port Oram, on the hill, it is good, but rather thin. Just south of Dover there has been some clearing near the town, but otherwise the hills are covered with a good growth, principally chestnut and oak, 6 to 16 inches in diameter and 30 to 40 feet high. Elsewhere in Randolph township it usually varies from 4 to 10 inches in diameter to from 6 to 16 inches, and there has been some recent cutting, but it is not extensive. The hills between Franklin and Rockaway are timbered with a growth 40 years old or younger. Some has lately been cut off, and probably one-half is less than 20 years old. West of Franklin, on the same ridge, it is from 6 to 10 inches in diameter, and 30 to 45 feet high, mostly oak and chestnut. The timber east of Den brook, over to Morris Plains, also appears to range up to about 45 years old, something near half being of this age, and the rest generally less than 20 years old. Oak and chestnut prevail. Near Camp Tabor several large trees have recently been cut, which had stood in the open with plenty of room. They were all 35 years old, measured from 24 to 34 inches across the stump, and were from 40 to 50 feet high, sound at the heart. A case was mentioned here of a wood lot, the timber of which was from 40 to 50 years old, for which an offer had been made of $100 per acre. The trees between Shongum and Morris Plains, and generally, in this vicinity, are about 44 years, all of which range from 6 to 24 inches in diameter and from 40 to 50 feet high. There are very few coniferous trees; mostly in the valleys and along the streams, On Trowbridge mountain, northeast of Shongum, a few acres of timber were noted, measuring from 10 to 30 inches in diameter and 60 feet high. A few red cedars were noted near Morris Plains, and also some near Shongum. The timber near Morristown seems to be older and better than it is further west. Generally, from Morristown, Mendham and Chester, on the south, to Ironia and Mount Freedom, on the north, either chestnut or oak predominates, but there is also a good deal of hickory, some birch, white birch, maple, elm, &c. There does not appear to be much cutting at present, but there has been a good deal 10 or 15 years ago, so that there is much timber only from 2 to 5 inches in diameter, but it runs from these sizes up to 20 inches. A fair average of the timber would be from 6 to 10 inches and 30 to 45 feet high. The steeper slopes are generally forested, and there is no evidence of washing from deforestation. On the easterly edge of the plateau, southwest from Morristown, the timber is of the same general character as that we have already described. As this is becoming a residence district there is a tendency to preserve the timber, and most of this is of fair size and age, and there is very little cutting. Further southwest, on Mine mountain, the growth is good and thrifty, ranging from 8 to 20 inches in diameter and 30 to 55 feet high. There is but little cutting, and what there is is mostly for fencing. It is mainly held either in connection with farms or the country places of people from the near-by cities, and there is a general tendency to cut the wood carefully and make the most of it. Over along the north branch of the Raritan there is some good timber, but most of it runs from 4 to 6 inches in diameter and 20 to 30 feet high. It is noticed that as we approach the red shale country there is generally more hickory and less chestnut. The region between Peapack and Chester has timber running from 6 to 14 inches in diameter and 30 to 50 feet high, but not much has been recently cut. A considerable amount was taken off between 10 and 15 years ago. There is good timber on Mount Paul, ranging from 6 to 12 inches in diameter and 25 to 45 feet high, and including about half a dozen white pines. Along the Black river, from Chester to Pottersville, the best timber has been or is now being cut, and the average growth is from 2 to 10 inches in diameter and 10 to 40 feet high. There are a few hemlocks near this stream.

Passing southwest, to the Fox Hill district, we still note that chestnut disappears at the edge of the red shale, while the oak and hickory is good, but only small parcels are left standing, most of the country from the foot of the Highlands being cleared. There is also a good deal of cleared land on the plateau, about Fairmount and southwesterly, but the small lots of timber left standing are generally good, ranging from 7 to 16 inches in diameter and 30 to 45 feet high. Still further southwest, about Cokesburg and toward High Bridge, there are only scattering parcels of timber left, and here, as on the south end of Schooley's mountain, what remains is being rapidly cut off. The timber continues to be mainly chestnut and oak, with the usual sprinkling of other varieties, but here also, as elsewhere, the disappearance of chestnut, when we reach the red shale country, is very marked.

It will be noticed from the foregoing detailed review and description of the Highlands forests, that the severest cutting at present is to the southwest, where the proportion of forested area is the smallest. Further northeast, cutting is by no means severe, and the timber is steadily improving. It is also apparent that there is very little tendency to wastefulness, that the cutting of timber is determined entirely by the demand, and this is true not only as to the amount cut but as to the age at which the timber is cut. In the past it was found profitable to cut timber for charcoal when 20 years old, and more recently for hoop-poles at a still earlier age; but, owing entirely to a change in the markets, this has all been altered, and the tendency at present is not to cut until the age of 30 years, or thereabout, has been reached. These facts as to the history of the past suggest at once that the same influences must determine how these forests shall be managed in the future. If there should come a demand which would make it profitable to cut at an earlier age than 30 years, it is difficult to see how such cutting can be prevented. It appears, however, that owners of the forest are ready for any suggestions which will enable them to derive a greater profit from their holdings, that they will not be slow to receive and adopt practical suggestions, or to improve on their present methods, and that a great deal can be done to aid the cause of forestry in this section of the State by instruction.

PASSAIC VALLEY.

This valley, lying between the trap ridges variously known as Watchung, or the First and Second mountains, and the eastern slope of the Highlands, is a portion of the red sandstone plain, and is all glaciated excepting the portion lying southwest of the line of the Delaware, Lackawanna and Western Railroad, between Summit and Morristown. This unglaciated portion, however, partakes to some extent of the character of the rest, rather than of the unglaciated portion of the red sandstone plain south of the trap ridges, both in the variety and the extent of its forest growth. This fact may possibly be due to the prevalence of gravel deposits traceable to Lake Passaic, which once occupied the whole valley, and partly due to a number of trap hills and ridges contained within the area; but, whatever may be the cause, it is a fact that the whole valley may be classed together in relation to its forests. Generally, the percentage of forested area ranges from 20 to 40, averaging for the whole valley about 30 per cent. Pompton plains is the most sparsely wooded section of the valley. Over the northern part, generally, oak from 10 to 20 inches in diameter and 60 to 80 feet high is common enough to indicate that the soil is able to produce heavy timber, but the prevailing growth is quite irregular both in size and variety, and is generally smaller than that above noted. Softer woods, such as gum, maple, willow, etc., prevail on the flatter portions of the valley. There are also over the cultivated portions many scattering trees, planted forest trees, fruit trees, etc., many of which are of a large size, so that a general view of the valley from any commanding point gives the impression of a well wooded country. Riker Hill, Hook mountain, and the other trap ridges within the valley have timber resembling closely that of the Watchung mountain ridges, which we shall describe later. They are generally covered with cedar trees. The original growth was oak and hickory, and this was succeeded, when cut, by the red cedar to a great extent. On Hook mountain the timber of the east end was cut about 35 years ago, some parts a little later. Some is now being cut for fencing, etc., the trees running from 20 to 30 feet long, and cutting posts worth one and one-half cents per foot. A portion of the mountain near Tom's point was cut off from 8 to 20 years ago, and the growth is slow, consisting of oak, hickory, chestnut and whitewood, but little cedar, and it is generally true that there is little cedar all the way down on the east slope of the mountain, but on the west slope, wherever the oak and hickory is cut off, red cedar comes up abundantly. In one place the original forest had been cut off not over three years ago, and scarcely a sprout could be seen excepting red cedar. The oak and hickory is large, some of it apparently over 100 years old.

On Long Hill the timber is short and thin, with a good many red cedars, and a very little timber that would pay to cut. There is very little chestnut on this ridge.

Around Troy Hills and northward to Boonton, the larger timber is cut, from time to time, for various uses, but the tracts being held in connection with farms are not cut off as a whole. Near Littleton some timber was sold 30 years ago for $60 per acre. Parsippany woods, east of Tabor, is about 40 years old, although a freshly-cut stump was noted 51 years old. The wood is light, 30 acres being recently sold for $20 per acre. Red cedars have come up here quite thickly, especially on former pasture lands. The wood is mainly oak and chestnut, and is all deciduous, excepting the red cedar. Along the road from Tabor to Parsippany there are some oak and chestnut trees which appear to be from 100 to 150 years old. North of Lee meadows there is some timber said to be worth $75 per acre. The balance of the tract has had the large trees cut out, leaving mostly trees of about 30 years' growth.

On Horse hill, east of Morris Plains, the timber is from 4 to 7 inches in diameter and 20 to 35 feet high, on the south end, while on the top and east slope it is from 10 to 20 inches in diameter, and toward the north end from 2 to 5 inches in diameter and 10 to 25 feet high, but here also there is some better timber, ranging from 6 to 24 inches in diameter and 25 to 45 feet high. The timber on this hill is mostly oak, with some chestnut, hickory and maple, and a good deal of red cedar about the clearings. About Malapardis, Whippany, Troy Hills and Parsippany much of the timber ranges from 6 to 18 inches in diameter and 25 to 50 feet high, but there is some 24 inches in diameter and 60 feet high. There appears to be no chestnut here, but mainly oak, hickory and maple, all looking thrifty, and there is very little cutting. There is also considerable red cedar hereabouts, and on the lower lands a good deal of pin oak.

On the uplands, between Pine Brook and Swinefield Bridge, timber averages from 6 to 12 inches in diameter and 30 to 50 feet high, with very little chestnut, being principally oak and hickory. It looks thriftier on the uplands than on the meadows, the best of the timber being pin-oak. On the ridge between Whippany and Passaic rivers, from Hanover Neck to Madison, the timber seems thrifty, and ranges from 7 to 12 inches in diameter and 30 to 50 feet high, and seems to be carefully preserved by the owners. Between Whippany and Morristown, also, it is good, ranging from 6 to 12 inches in diameter and 30 to 55 feet high, but, for the most part, there is a little too much brush and young growth. There does not appear to be any chestnut, excepting along the banks of Whippany river, until we approach Morristown, and there is less red cedar than elsewhere. The timber is also quite good on the ridge near Convent, ranging from 6 to 24 inches in diameter, but there is considerable small growth mixed through it. There is a little chestnut between Hanover and Chatham, and the timber here is also thrifty, ranging from 4 to 24 inches in diameter, with most of the trees between 7 and 11 inches. South of Madison, on the ridge, timber ranges from 6 to 24 inches in diameter and from 30 to 60 feet high, this being much larger than most of the timber in this neighborhood. The different kinds of oak predominate, but there is also some chestnut and hickory, with a few elms, maples, &c. On the upland, bordering the Great swamp, most of the oak appears to have been cut out within three years. There are quite a good many chestnuts and hickories. The larger trees left standing are from 6 to 11 inches in diameter and 25 to 40 feet high. There is, also, quite a good deal of brush and underbrush, with a good many young cedars. North of Green Village the timber is good, that is, what remains of it, but some has been cut within a few years. What remains runs from 6 to 10 inches in diameter and 30 to 45 feet high, with a few trees as much as 24 inches in diamter. It is principally oak and hickory, with some chestnut, maple, birch, &c. Northward of Green Village, and toward Morristown, timber is generally from 4 to 24 inches in diameter and from 20 to 50 feet in height, most trees ranging from 6 to 10 inches in diameter. The owner of a portable saw-mill has just cut off a tract between Silver lake and Madison. On the southwest slope of the ridge, between Madison and Morristown, timber ranges from 6 to 11 inches in diameter and from 30 to 55 feet high, with some trees as much as 24 inches in diameter. It consists of oak, chestnut, hickory, maple, elm, birch, etc., with a good deal of cedar in places. Some of this timber has been trimmed out. In the neighborhood of New Vernon the average timber ranges from 6 to 12 inches in diameter and 25 to 50 feet high. There are some pieces of young growth, and again there are tracts with trees 24 inches in diameter and 50 to 60 feet high. As a general thing there is little chestnut, excepting near the foot of the Highlands. Oak of all kinds predominates, especially white oak, and, on the flat places, pin-oak. We also find some maple, beach, elm, birch and white birch, with red cedar everywhere where old clearings have grown up. There has been very little cutting on this tract, between Morristown and the Great swamp, within the last 4 or five years.

On the northeast end of the Great swamp, near the edge of the uplands, there is a good deal of small growth, including red cedar. Further in the swamp the wood appears to be better, the larger trees ranging from 6 to 24 inches in diameter and 30 to 50 feet high. Larger sizes are not numerous, and a great many pin-oaks were noted. Along the edge of the swamp, next to Long Hill, a good many red cedars were found about the neglected clearings, and it also appears to have succeeded the timber where it has been cut off. The timber in the swamp consists of oak, largely pin-oak, maple, birch and elm, with a few chestnuts, the latter growing only on the high ground. Taken as a whole, the timber in this swamp is very poor. One hundred acres in the southern part was cut off last year. The best timber is said to be near White Bridge, but good timber was also noted near the northeast end of the swamp, elsewhere the larger and better trees have been cut out. This cutting has been especially severe during the last 10 years. In the valley, along the river above Chatham, the most of the timber is either close to the stream or in widely separated clumps, much of the valley being under cultivation. A good deal was noted ranging from 6 to 24 inches in diameter and from 30 to 50 feet in height, but some is smaller. Generally this valley timber is thrifty and better than that on the adjoining ridges. The best of it is just west of New Providence. There is almost no chestnut here.

In the northern part of the valley it is estimated that swamp land timber of the older and heavier growth is worth, on an average, about $50 per acre, and upland timber of about the same age, $100 per acre, supposing, in each case, that the timber is mostly oak and hickory. It was claimed that stump-land was worth from $20 to $40 per acre, but this estimate evidently does not consider swamp lands, which are generally worth less than this after the timber is cut off. Here, as in other portions of the State, the ordinary rule is followed to estimate for 30 years' growth a yield of 30 cords per acre, and thereafter about one cord per acre for each year that the timber has been growing. Observation seemed to indicate that most of the timber grows less rapidly after reaching about 30 years of age, and the largest yield is thought to be obtained by cutting it between 30 and 40 years old, especially if the growth is largely chestnut, as this timber often deteriorates as it grows older. There is some difference of opinion as to whether this deterioration is, or is not, increased by continual reproduction from the old stumps without re-seeding, but the general trend of opinion is that this is at least increasing the tendency of chestnut to decay at the heart. If this is the cause it will be advisable to begin re-seeding when timber is cut off.

WATCHUNG MOUNTAINS.

These two trap ridges have from 40 to 60 per cent. of their entire area covered with forest, the average being not far from

60 per cent. There is much more timber than on the Passaic valley to the westward, but the contrast is still sharper with the deforested country south and east.

North of Campgaw there is an unbroken tract of about 2,000 acres of timber, covering the trap hill. It is principally chestnut and oak, about 50 feet high, and from 6 to 12 inches in diameter in the northern portion, and from 20 to 40 feet high and 3 to 8 inches in diameter in the southern part. From Campgaw, by Sicomac to the Goffle, the timbered areas are more scattering, and also more varied in character, but oak and chestnut are still predominant. Over all these trap ridges red cedar prevails, springing up spontaneously and persistently in abandoned clearings. It is generally less than 20 feet in height. The Goffle has some good oak and chestnut timber 50 to 70 years old, from 50 to 70 feet high, and 10 to 14 inches in diameter. On Preakness mountain, and the ridge just west, the growth is largely mixed with red cedar, and is of an inferior size and quality on the trap, being much better on the red sandstone portion of the eastern slope near the foot. Near Pompton lake there is considerable good hemlock, this last being a rather unusual growth for this part of the State. Second mountain, about Caldwell and northward, has some fair oak, chestnut and hickory. First mountain is not so well timbered, and has more red cedar. Abandoned clearings are quite frequent, and the whole of the growth is irregular and patchy. Most of the timber is also younger than that in the Hackensack valley. There is a noticeably greater prevalence of hickory on the trap than on the red sandstone.

Southwest from Caldwell and Verona the timber ranges, generally, from 4 to 12 inches in diameter, and 20 to 45 feet high. There is very little chestnut, excepting near Montclair, on First mountain. On the same ridge, at Eagle Rock, the timber is small. Around St. Cloud the growth ranges all the way from 2 to 12 inches in diameter and from 10 to 45 feet high. On the east slope of First mountain, from West Orange to Wyoming, there is also much variation in the size. The west slope seems rather better wooded, ranging from 6 to 24 inches in diameter, with the larger part from 8 to 12 inches, and there is less young growth. On Second mountain, about

Livingston, the timber is mostly oak and hickory, with very little chestnut. There is a good deal of small growth, but there are some trees ranging up to 24 inches in diameter. There is also much red cedar. Around Livingston there has been more clearing-away of forests for cultivation than anywhere else noted. The timber on these ridges, here as elsewhere, continues to be inferior to that in the adjacent valleys. Near Northfield, a piece of timber was noted, about the best of any in the vicinity, ranging from 6 to 24 inches in diameter and 30 to 50 feet high. This lot contained 19 acres, and had just been sold, including land and wood, for $600. It was estimated that it would yield 28 cords per acre. Over this part of the mountain the timber ranges all the way from 2 inches up to 18 in diameter and from 10 to 45 feet high, with a large proportion of the smaller sizes, but some scattering trees are as much as 24 to 28 inches in diameter, the poorer timber being, generally, toward the top of the mountain and on the eastern slopes, but for two or three miles north of Millburn there is an exception to this rule, as the timber is good, and ranges from 6 to 24 inches in diameter. Around Short Hills and Summit there is a good deal of chestnut again, and not much cedar. Southerly from South Orange turnpike, First mountain and the valley west contain some pine. There is also a little hemlock along the Passaic near Stanley, and again near Millington. There is also a little pine on Long hill near Stanley, and on Second mountain, south of Murray Hill. Continuing southwest from Summit, the best timber continues to be on the west slope of the mountain. The various kinds of oak prevail, with chestnut, hickory and the other usual varieties. For the most part the wood is poor and appears to be stunted, although it is claimed that it can be profitably cut in 20 years, but our examination seemed to indicate that 40 years would be generally necessary, and even then the growth would be much inferior to that of the adjoining valleys. There is much of this timber ranging from 2 to 4 and 6 inches in diameter and 10 to 30 feet in height, with a little ranging up as high as 18 inches in diameter and 50 feet high. Continuing southwest of the road from Basking Ridge to Bound Brook, the timber becomes still poorer; the trees appear to be old, but are short and stunted. Continuing on around to Basking Ridge, the same conditions, generally, prevail, the wood being mostly small, but with a few large trees. Throughout the whole extent of the ridges, red cedar appears to be abundant about the edges of the clearings, and where the clearings have grown up. Not much cutting was noted, as the growth was too small to make it profitable. The woods consist of oak, hickory, maple, birch and beech, with a little chestnut. We are inclined to think that the general inferiority of the timber of the trap ridges arises, partly from the nature of the trap-rock soils, and partly from the fact that these ridges are very accessible to a thickly-settled country, where timber is comparatively scarce, and, in consequence, cutting has probably been more severe than elsewhere. As a result of these two causes the timber is deteriorating. On the whole, the tendency on these ridges seems to be to allow clearings to grow up, but as they have, within a few years, become occupied, to a great extent, by an immigrant population, this tendency may, possibly, be reversed, owing to different methods of farming. It may be mentioned, in this connection, that the curious fact has been noted, in our forest studies, that there is less disposition to destroy and waste the forests shown by our native rural population than by the immigrant population from countries where the control and management of forests is, on the whole, far superior to our own methods.

HACKENSACK VALLEY.

The red-sandstone country lying between Palisades mountain on the east and Ramapo and Orange mountains on the west was designated by us the Hackensack valley, in the "Physical Description." Topographically, it is all one valley, although not all drained by the Hackensack river. It includes all of Bergen and Hudson counties, Passaic county southeast of Paterson, and the northeastern corner of Essex county. It contains a large urban and suburban population, and it seems somewhat anomalous that it should also include some of the best timber of the State. The valley, as a whole, has 30 per cent. of its upland area in timber, or, in other words, 61,000 acres in a total of 180,000 acres of upland. Bergen county has 39 per cent. in timber, Hudson county only 5 per cent., the Passaic county portion 9 per cent., and the Essex county portion 20 per cent. In topographical position this timber is largely confined to the slopes, level valley bottoms and plateaus being mainly under cultivation. These cultivated portions, however, have a very liberal allowance of scattering forest trees, orchards and other planted trees, so that in looking over the valley from an elevation it appears to be very generally wooded. The really forested portion ranges through all conditions, from a very limited amount of brush and stump land to heavy timber. Very little of it is now cut off entirely, most of the cutting being selected trees, so that the considerable amount of timber taken out each year is scarcely missed. There is no wastefulness apparent, as a rule, in the handling of the forests. It is generally a mixed deciduous growth, with oak predominating in the lower land along the Hackensack, while chestnut prevails on the higher ridges westward, and softer woods, such as gum, white birch, beech and maple in the swamps. Here and there are few scattering hemlocks. From Closter to Englewood there is much red cedar. The timber is usually in rather small, isolated areas, not often reaching 100 acres in extent. There is a tract of some 500 acres along the Hackensack near the State line. Proceeding southward from the State line, across the whole width of the valley, there is a gradual decrease in the amount of timber. The growth in the vicinity of Ramseys to Wyckoff is rather mixed, consisting of oak, chestnut, maple, beech, elm, white birch, red cedar, &c., in all stages of growth, from brush to trees 80 feet in height, but there is a notable absence of stump land or new clearing. Near Paterson the country is quite deforested, the 9 per cent. of forest in the Passaic portion of the valley consisting mainly of small patches of oak and chestnut, preserved in connection with farms, and only cut occasionally and sparingly as needed. Most of the groves contain much fine timber, and are generally well cared for. Proceeding southwest into Essex county the wooded area is increased to 20 per cent. and is somewhat similar to that described, although the timber is, as a rule, not so good. There are some quite large timber areas north of Belleville. In this Hackensack valley, as a whole, the timber is probably as well cared for as in any other equally large section of the State. It is thrifty and healthy, and suffers comparatively little from fires.

The value of the land here is, of course, generally much too high for profitable forestry. In well-located places it is worth from $400 to $1,000 per acre, where it is still sold by the acre instead of by the foot. In a few out-of-the-way places it ranges lower, but is in any case largely independent of the character of the timber. From inquiry, it was estimated, however, that the timber alone was worth from $30 to $50 per acre for a 30-years' growth, and in proportion for younger timber, but old timber of mixed varieties is worth from $100 to $150 per acre. Swamp land timber is said to be rarely worth more than $20 per acre. In the vicinity of Wyckoff we obtained the following general prices: Stump land, $5; 20-years' growth, $15 to $25; 30-years' growth, $25 to $35; large oak and chestnut, $75 to $100 per acre. About Oakland, stump land, $3; 20-years' growth, $20; 30-years' growth, $30; large mixed growth, $60. In such inquiries as this it becomes quite evident that many of the estimates given are based on the prevailing rule that timber will produce one cord of wood per acre for each year that it is growing, and that this wood is worth about $1 per cord on the stump, as was determined by a large number of written inquiries sent out by the Survey, the results of which were published in the Annual Report for 1885. This rule seems to prevail all over the State, but it is quite evident that it cannot be equally fair for all sections, although probably a good working average.

A few tracts claimed to be original forest were noted in the Hackensack valley. One is half a mile east of Hillsdale, containing about 30 acres of oak, 15 to 28 inches in diameter and about 70 feet high; a small piece of oak, one-half mile south of Riverdale, another, one mile west of Englewood, containing oak from 15 to 30 inches in diameter and from 60 to 80 feet high, and another piece of oak, one mile northwest of Oradell, on the ridge. It is noticeable that all of these tracts are of oak.

Several large trees were noted throughout the valley. At Hohokus, a fine elm 50 inches in diameter and 80 feet high, with a spread of branches of about 100 feet; one mile southwest of Etna, an oak 46 inches in diameter and 60 feet high; in an old clearing, one mile northeast of Saddle River, two chestnuts each 60 inches in diameter; on the estate of the late Hon. W. W. Phelps, at Teaneck, two oaks 40 inches in diameter; at Ridgewood, a chestnut 60 inches in diameter; at Haworth, a chestnut 84 inches and another 78 inches in diameter; north of Arcola, a chestnut 72 inches in diameter; at Overton, a chestnut 76 inches in diameter. Most of these chestnuts are only remarkable for girth, but near Oradell there is a fine chestnut tree 63 inches in diameter and 55 feet high; at the forks of the road, a little over one-half of a mile north of Ramseys, a chestnut 60 inches in diameter and 50 feet high; another, three-quarters of a mile northwest, 60 inches in diameter and 45 feet high. Near Campgaw we noted a chestnut 62 inches in diameter and 60 feet high, and two others 66 inches in diameter and 50 and 60 feet high; north of Wyckoff, a large white-wood 36 inches in diameter and 80 feet high; near Wortendyke, a chestnut 48 inches in diameter and 65 feet high. Near Paterson chestnuts were noted 36 to 60 inches in diameter and 60 feet in height; also, two large black walnuts, near the river, northeast of Paterson, 42 inches in diameter and 60 feet high. The total consumption of saw-mills in this district was ascertained by inquiry to amount to practically 2,400,000 feet, board measure, of lumber, and besides this kindling-wood factories consumed the timber from about 25 acres annually. The whole consumption by these mills would, therefore, probably not exceed the growth from 85 acres annually. Besides this use, however, there is the consumption for railroad ties, telegraph and telephone poles and fuel, the amount of which has not yet been ascertained.

As regards the succession of growth, the general opinion seems to be that it is of the same kind as that cut off, although some claim that white oak and hickory are followed by a more mixed growth. It is evident that since cutting-off of entire areas of timber seems to have been long ago abandoned in this vicinity, and most of the cutting is by culling out, there cannot be much reliable data obtained on this point; at Moonachie, maple is said to have succeeded oak, and at other places the succession has been chestnut. There is no room for doubt, however, that as a rule abandoned clearings, which have once been cultivated, grow up in red cedar, although this is occasionally accompanied by, or replaced with, white birch.

Groves of planted white pine may be seen on the estate of the late William Walter Phelps, and also one mile east of Saddle River, south of the road from Ridgewood to New Milford.

PALISADES MOUNTAIN.

It will be a surprise to many to learn that this ridge, so near to the large cities, and in the most populous section of the State, is so well wooded. From the State line, south to Edgewater, a distance of 13 miles, and for a width of 1½ miles back from the bank of the Hudson, practically 90 per cent. of the whole area is well timbered. The forest covers an unbroken tract of 11,000 acres. Beginning at the State line and extending to 1 mile below Huyler's landing, we have, on the talus slope along the river, a mixed deciduous growth, mainly chestnut and oak, from 30 to 60 feet high, varied with pine and hemlock near Huyler's landing. We give here, as elsewhere, only the prevailing timber, but in reality this whole Palisades forest includes a large number of varieties. Further down, to Linwood, the growth on the talus is more irregular, containing a fair proportion of oak and chestnut of good size, with scattering hemlock. From Linwood to Fort Lee the talus is well wooded, some good white pine being found, but oak and chestnut prevail. From Fort Lee to Edgewater the river slope of the ridge is well timbered, but a strip of land along the river, at the foot, has been cleared and occupied by residences. On the flat top and upper portion of the western slope of the mountain, from the State line to Edgewater, if we except some red cedar near the State line, the growth is practically of mixed deciduous varieties, mostly oak and chestnut. This timber ranges from undergrowth to trees 40, 60 and 80 feet in height. Diameters of from 20 to 30 inches, and heights of from 60 to 80 feet, are not at all uncommon, especially from Huyler's landing to Edgewater. Taken as a whole, there are not many finer belts of timber in the State. The land is largely held in such a way that there is comparatively little danger of wholesale deforesting, but this beautiful forest has almost as good a claim to future preservation as the escarpment of the Palisades. South of Edgewater the ridge is practically a city to Bergen Point, and entirely deforested.

REMAINDER OF GLACIATED RED SANDSTONE.

In the four topographical subdivisions last considered, viz., the Passaic Valley, Watchung Mountains, Hackensack Valley and Palisades Mountain, we have included all of the glaciated red sandstone except the portion east of the Watchung mountains, extending from Newark and Orange southwest to the moraine at Plainfield and Perth Amboy. This remaining country, drained by the Elizabeth and Rahway rivers, is heavily covered with drift in irregular hummocks and ridges, and is not specially adapted for agriculture, but is being occupied by suburban homes in the north, while southerly it is the well-known clay district of Middlesex county. In general, about 25 per cent. of the upland area is in forest.

North of Westfield and Fanwood chestnut prevails, mixed with oak, hickory, maple, etc. The wood looks thrifty. Some is less than 20 years old, but more is older, and averages from 6 to 14 inches diameter, and 40 to 65 feet high. Just northwest of Westfield some trees ran up to 24 inches diameter and 70 feet high. Northwest of Cranford some ranged from 4 to 12 inches diameter and 40 to 50 feet high, some 6 to 12 inches by 45 to 55 feet, and a few large trees were mixed in which ranged up to 20 inches by 70 feet. Along Rahway river the timber is small, having been culled out. In the swamp at Union it is poor, with much white birch. North of Roselle it was 6 to 24 inches and 50 to 75 feet high with some few pieces smaller, but all healthy. All of the above is oak, chestnut and hickory, principally.

Southeast of Fanwood it is of the same general character; large and thrifty. Near Netherwood it is a little smaller. Southward from Westfield and Cranford the same general conditions prevail, but the timber of Ash swamp is smaller, 2 to 14 inches by from 20 to 60 feet. Southeast of the Pennsylvania railroad, between Rahway and Elizabeth, pieces of timber ranged as follows: 2 to 6 inches by 20 to 40 feet; 6 to 24 inches by 50 to 60 feet; 6 to 20 inches by 40 to 50 feet; and 8 to 14 inches by 35 to 55 feet. Near New Dover the smallest timber ranged 2 to 7 inches in diameter by 10 to 20 feet high, and the largest 8 to 24 inches by 40 to 70 feet. The various parcels ranged through all intermediate sizes.

An oak along road north of New Dover measured 4 feet one way and 5 feet the other way, 2 feet above the ground. It branched 5 feet above ground, having a spread of branches of 75 feet, and was 50 feet high.

Along the Pennsylvania railroad southwest from Iselin, a small piece of timber showed 150 trees per acre, from 6 to 24 inches in diameter and 50 to 70 feet high, including chestnut, oak and hickory.

North of Woodbridge, to Rahway river, the condition of the forest is very similar to that heretofore described; and it comprises oak, chestnut and hickory of all sizes, ranging up to 24 inches diameter and 75 feet high. Southward there are some conifers mixed with the deciduous trees. Near Perth Amboy it appears as if most of the larger trees have been culled out of the standing timber.

UNGLACIATED RED SANDSTONE.

Passing southwest of the moraine, which crosses from Fanwood through Metuchen to Perth Amboy, we enter immediately an agricultural district. The change is sudden and striking. The forest area suddenly drops from about 30 to 10 per cent. of the total area, this consisting almost exclusively of small woodlots attached to farms and husbanded for fuel, fencing and other domestic uses. Much of this is fine timber—as good as any in northern New Jersey.

East of Bonhamtown, in the clay district, the timber is small, appearing as if the larger trees had been culled out. Much of it is 2 to 6 inches in diameter by 10 to 30 feet high, with a small number of larger trees, up to 16 inches diameter.

Near Piscataway there has been much cutting within 15 years or so, and the young growth has started up too thick. A few large trees are left standing. Some timber is 6 to 24 inches diameter by 40 to 60 feet high. Going toward Stelton, some trees 36 inches in diameter were noted. Chestnut prevails, with some oak and hickory. A maple tree near Piscataway measures 42 inches diameter and 50 feet high. A chestnut near Bonhamtown, at 2 feet above ground measures 54 by 90 inches diameter and 50 feet high, with a spread of branches of 50 feet. An oak near the same place measures, at 2 feet above ground, 54 by 66 inches diameter and 60 feet high.

In Piscataway township many red cedars were noted standing along fence lines or in old clearings. The timber is all in small clumps attached to farms, and there is evidence that originally it was heavy. Many trees still standing range up to 18 inches diameter and 60 feet high. There is much white oak, with all other varieties of oak, hickory, gum, beech, maple, etc., but very little chestnut.

Mr. William McAdam, living near the Dismal swamp, northwest of Metuchen, mentions a 16-acre tract of original timber in the swamp. In it are trees that will square 6 inches at 60 feet from the ground. It consists of white oak, pin oak and hickory. Some trees are 80 feet high. One white oak was cut which measured 8 inches diameter 75 feet from the ground, and another 16 inches at 56 feet high. He says that through that country from 50 to 100 telegraph poles per acre can be got, but this leaves little cord-wood. An acre will yield from 20 to 40 cords of wood, and $40 per acre is a fair average value for timber. He gets $10 each for telegraph poles 60 feet long and 6 to 7 inches diameter at top, and $4 apiece for poles 35 feet long, delivered on the cars.

He also mentioned a hickory tree which was 6 inches diameter 70 feet from the ground. A piece of oak, 30 years old, which he pointed out, was from 4 to 7 inches in diameter. He says there is much valuable timber in that part of Middlesex county which does not appear good until closely examined, because of the small growth about the edges of the woodland.

In Franklin township, Somerset county, conditions are similar to those just described for Piscataway township. Near East Millstone, a tract showed 210 trees per acre, measuring 6 to 24 inches diameter by 50 feet high.

Between Rocky Hill, Griggstown and Sand Hills, on the trap and gravel, there are considerable forest areas. That on the Sands Hills is mostly chestnut. The various lots range in size from 2 to 8 inches diameter, and 10 to 30 feet high, up to 5 to 13 inches diameter, and 25 to 50 feet high. The best timber appears to be near Griggstown.

An oak tree, near Franklin Park station, measured 52 inches diameter, and about 50 feet high. Timber near here ranged from 4 to 28 inches diameter, and was about 50 feet high, principally of oak and hickory, with a little chestnut.

Near Finderne there are four chestnut trees in a cluster, over 30 inches in diameter, and 40 feet high. These are on a gravel terrace. Chestnut is almost unknown on red-shale soil. An oak tree, near the above chestnuts, measures 52 inches diameter. Another, further south, is 66 inches in diameter, 55 feet high and with a spread of limbs of 90 feet. North of Hillsboro station a wild cherry is 52 inches diameter, and about 50 feet high.

On the plain between Millstone river and Sourland mountain, along the Philadelphia and Reading railroad, there is very little forest. The largest piece, southwest of Millstone, is about half as large now as it is shown to be on the topographical map. The trees of the various lots run in size from 2 to 10 inches diameter up to 8 to 30 inches, and are mainly white oak and hickory.

Southeast of Somerville is Pigeon swamp, a tract of original forest, containing about 250 acres, and the heaviest timber in this section.

On the end of Rocky Hill, near Hopewell, the timber is light, 3 to 10 inches diameter and 40 feet high. It improves going eastward, is good about Mt. Rose, but further east is again poor, has all been cut over, and what is left ranges 3 to 14 inches diameter and 30 to 45 feet high, appearing to be not very thrifty. Although chestnut does not grow on the surrounding red shale, it is prevalent over this and the other trap ridges. The end of the ridge just west of Millstone river has many trees which average about 9 inches diameter by 45 to 50 feet high, but there is also a good deal of brush and young sprouts, or thin stands of trees.

A small tract of original forest just west of Millstone river and south of Rocky Hill village gave, by actual count, 163 trees per acre, measuring 10 to 24 inches diameter and 40 to 60 feet high. One-twelfth were chestnuts and the rest oak.

Twin chestnut trees east of Cedar Grove, forked 3 feet above ground, one was 36 and the other 33 inches in diameter and both about 55 feet high.

Along Stony brook, about a mile above Moore's Station, is an oak which is mentioned in records dated 1697.

A beech near-by measures 36 inches diameter at ground and 29 inches 10 feet above, is 40 feet high and has a spread of branches of 75 feet.

From Hopewell and Pennington southwest to the Delaware, the trees in some lots run from 2 to 8 inches diameter by 20 to 30 feet high, and in other lots from 6 to 20 inches diameter and 40 to 60 feet high. There has been considerable cutting of timber, but no clearing of land for cultivation.

From Pennington to Trenton the timber does not differ from that on the red sandstone soil which we have previously described, excepting that it is perhaps more thrifty. Near the State Asylum are trees measuring from 6 to 48 inches in diameter and 65 feet high. Good timber was also observed near Trenton Junction. East of Ewingville is a tract comprising some 400 acres, principally oak and chestnut, with some hickory, beech and maple. A part of this is fine timber, 6 to 36 inches diameter and 55 to 70 feet high. The chestnuts run up to a good height without branching. A count gave 255 of these trees to the acre.

Large trees were noted in this district as follows: East of Somerset, on a hill, a hickory 42 inches diameter and 70 feet high, with a spread of branches of 40 feet, the lowest branches being 9 feet from the ground; near Hillcrest station, an oak 36 inches diameter and 50 feet high, with a spread of 100 feet; north of the 400-acre tract, near Ewingville, a pin oak, 72 inches diameter two feet above ground, and 42 inches diameter near the forks, 7½ feet up, with a height of 55 feet and a spread of 60 feet; and in front of the Presbyterian parsonage, at Lawrenceville, two oaks, the easterly one measuring 54 by 66 inches in diameter two feet from the ground and the westerly one 51 inches diameter. These trees stand only one foot apart and their branches spread from 40 to 60 feet.

The red-shale country, extending from Somerville and Flemington northward to Peapack and the Highlands, is deforested. The small wood-lots attached to farms only represent about 3 per cent. of the entire area. There are scattering trees, hedgerows, orchards, and strips of timber in the little ravines, however, which to some extent make up for this lack of woodland. The timber is mostly oak and hickory, and there are many large trees, probably of the original forest.

West of Raritan and north of the railroad the timber contains some old trees up to 24 inches in diameter and 60 feet high, but the most of it averages 8 inches in diameter. South of the railroad is some heavy timber, from 18 to 42 inches diameter and 50 to 60 feet high, and a count gave 204 trees per acre.

At the mouth of Middle brook, north of Burnt Mills, is the McDowell tract, from which the timber has recently been cut. The trees ran from 8 to 36 inches in diameter, and a count gave 95 oaks, 95 hickories and 6 maples to the acre, 196 trees in all. One tree was sold recently for $16, at the rate of one and one-half cents per foot, which would make the tree yield 1,066 feet B. M. Two years ago the owner was offered $500 for 10 acres of timber. A piece south of river was sold for $1,000, and contained 20 acres. Tracts north contain some trees as large, but they are not so numerous.

Red cedar trees are numerous in this country, and especially so east of Mechanicsville. In nearly all cases no land has been permanently cleared for cultivation, and very little has been entirely cut off. The larger timber is cut out as needed.

Serious wash or erosion of the soil was observed between Greater Crossroads and Lamington, worse than has been observed elsewhere in the State. About a mile west of Readington a tract of 40 acres has been cut off and permanently cleared up. An oak stump here showed 190 rings and measured 30 inches diameter.

North of Barley Sheaf a count gave 380 trees per acre, measuring from 6 to 24 inches diameter and 40 to 50 feet high. Most of these were 14 to 18 inches in diameter. Cushetunk mountain has not much heavy timber. It ranges from 4 to 16 inches in diameter, and is chestnut, oak and hickory.

On Sourland mountain the area of forest is considerable, aggregating over 10,000 acres, but it is not heavy timber, perhaps mostly from 6 to 15 inches in diameter. It is mostly oak, hickory and chestnut, with some maple, beech and other varieties.

In the valley northwest of Sourland mountain, from Flemington to Lambertville, the red shale is deforested, only wood-lots remaining, attached to farms and representing perhaps 5 per cent. of the acreage. The trees of the several parcels range from brush 20 or 30 feet high up to trees 8 to 30 inches in diameter and 40 to 60 feet high.

The West Hunterdon plateau has more forest; about 12 per cent. against 3 or 4 per cent. on the lower red-shale country. The timber is also better. Near Sergeantsville it runs from 4 to 16 inches in diameter and 30 to 50 feet in height. One and one-quarter miles west there is original forest, the oaks running up to 24 inches in diameter. This piece also has white pine and common pine up to 20 inches in diameter. It is good, heavy timber. A large piece, two and a half miles east of Locktown, is also heavy. It is owned by Mr. Bearder, who allows no cutting. It is principally oak and hickory, 8 to 24 inches in diameter and 40 to 60 feet high. A count showed 156 of these trees to the acre.

Other pieces of oak and hickory near the above were 8 to 20 inches in diameter and 40 to 55 feet high, counting 136 trees to the acre. Much of the forest southwest from Headquarters is original forest. The trees measure from 6 inches to 36 inches in diameter and 40 to 60 feet high. There are many fine oaks and chestnuts.

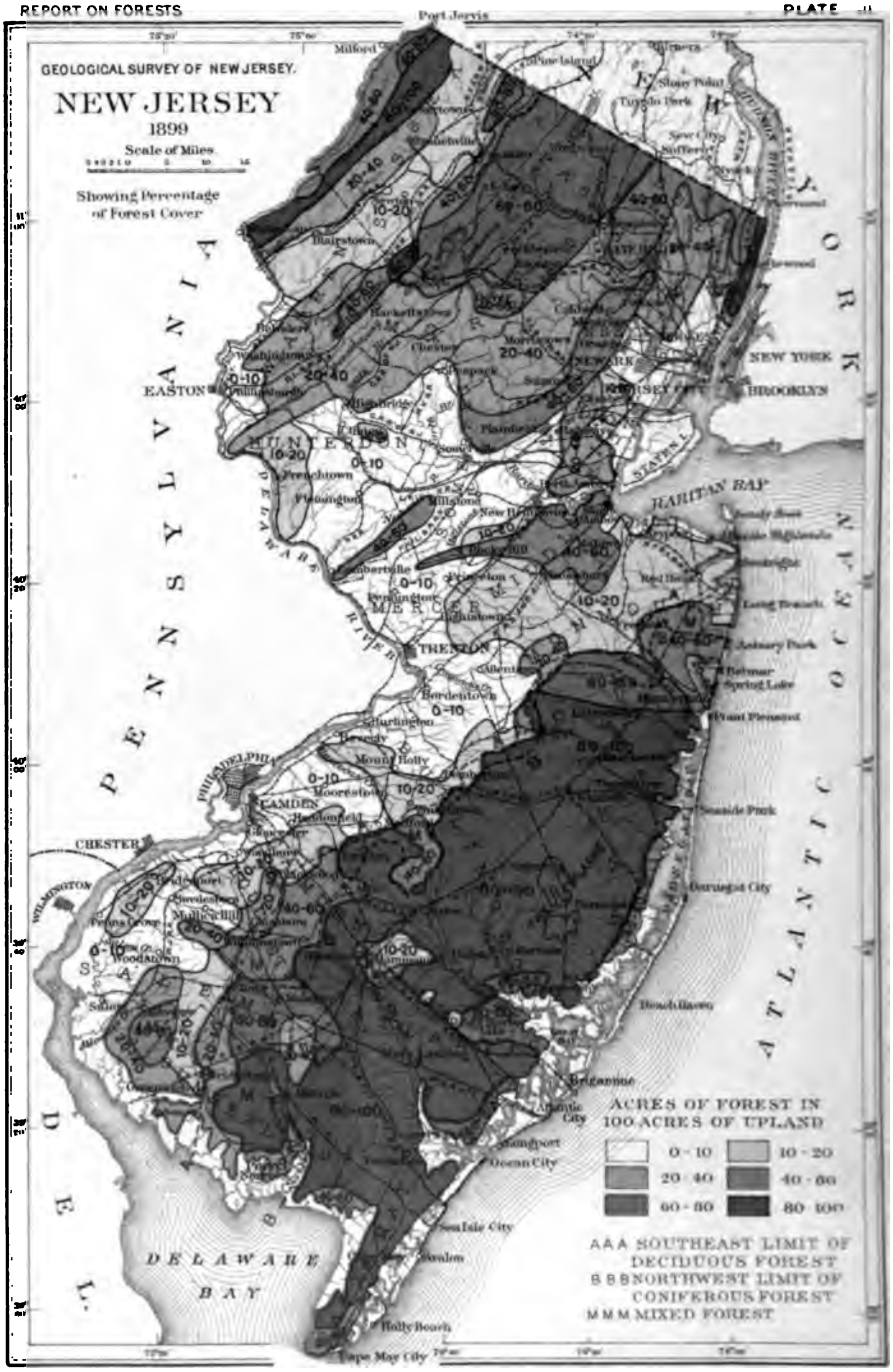
Northwest of Raven Rock is some excellent timber, from 8 to 28 inches in diameter and upwards of 50 feet in height. Along Lockatong creek some is also very good.

Southwest of Flemington, a piece of original forest contained 160 trees per acre, measuring from 8 to 36 inches in diameter and from 40 to 70 feet high. Some run up 40 feet without branching. It is said that, 25 years ago, $100 per acre was offered for this timber, but that now it is not worth over $40 per acre. It is oak, hickory, chestnut, maple, etc. Near by is another tract of 30 acres, mostly hickory, with some oak and chestnut, which runs from 8 to 18 inches in diameter by 20 to 55 feet high. An oak tree near by measures 60 inches in diameter, branches 10 feet up, and has a spread of branches of 50 feet.

Along Wickecheoke creek, north of Locktown, the trees are 6 to 24 inches in diameter, mostly pin-oak. One pin oak was noted 36 inches in diameter and 50 feet high.

South of Oak Grove there has been some clearing. Timber is good but thin. At one place there were 136 trees per acre 8 to 20 inches diameter by about 40 feet high. Another tract gave 204 trees per acre 8 to 24 inches in diameter by 30 to 50 feet

PLATE II


GEOLOGICAL SURVEY OF NEW JERSEY.
NEW JERSEY
1899
Scale of Miles
Showing Percentage of Forest Cover
ACRES OF FOREST IN 100 ACRES OF UPLAND
0 - 10
10 - 20
20 - 40
40 - 60
60 - 80
80 - 100
AAA SOUTHEAST LIMIT OF DECIDUOUS FOREST
BBB NORTHWEST LIMIT OF CONIFEROUS FOREST
MMM MIXED FOREST
PENNSYLVANIA
NEW YORK
ATLANTIC OCEAN
DEL.
DELAWARE BAY
DELAWARE RIVER
RARITAN BAY
HUNTERDON
MERCER
Port Jervis
Milford
Blairstown
EASTON
Phillipsburg
Washington
Hackettstown
Chester
Morristown
NEWARK
JERSEY CITY
NEW YORK
BROOKLYN
Frenchtown
Flemington
Lambertville
Princeton
Pennington
Hightstown
TRENTON
Bordentown
Burlington
Mount Holly
PHILADELPHIA
CAMDEN
Moorestown
Haddonfield
CHESTER
WILMINGTON
Woodstown
Salem
Long Branch
Asbury Park
Belmar
Spring Lake
Point Pleasant
Seaside Park
Barnegat City
Beach Haven
Brigantine
Atlantic City
Somers Point
Ocean City
Sea Isle City
Avalon
Holly Beach
Cape May City
Red Bank
Tuxedo Park
Bridgeton

high. A bit of original forest contained 200 trees per acre from 4 to 30 inches in diameter and 40 to 60 feet high.

A hickory stump near here was 38 inches in diameter and had 300 annual rings, as near as they could be counted. It was reported that 40 acres of timber had been sold for $1,000, and the same parties said $80 per acre had been paid near Whitehouse.

Between Oak Grove and Baptistown the trees ran from 4 to 14 inches in diameter and 30 to 40 feet high, standing close, or with thick undergrowth. Between Kingwood and Locktown a piece of original forest had 184 trees per acre 6 to 30 inches diameter and 50 feet high.

On the slope east of Cherryville some forest, said to be original, has trees 6 to 20 inches in diameter and 40 to 55 feet high. Between Cherryville and Oak Grove there is some still better timber. From Quakertown to Croton some timber is good and some has been cut off within 15 years. The timber is chestnut, oak, hickory, maple, and considerable pin oak. The level top of this plateau is known as "The Swamp." Chestnut is not as prevalent up here as it is on the surrounding slopes.

In general, the forest of this Hunterdon plateau is perhaps the best of the State.

PINES BELT—NORTHWEST BORDER.

The line which divides the deciduous timber from the coniferous, forming the northwesterly border of the pine belt, was carefully examined and surveyed. There is generally quite a broad belt of mixed timber along the border, so that we have traced upon the accompanying map both the northwesterly limit of the timber which may be said to be practically all pine, and the southeasterly limit of that which is all deciduous. Between these lines is the belt of mixed deciduous and coniferous timber to which we have referred, varying in width from a few yards to eight miles. There are, however, isolated areas included within the pine district which are much mixed with oak. Some of the older residents of the district are of the opinion that, generally speaking, there is much more oak than there was forty years ago. Oak usually comes up to replace pine which is cut off, excepting where the land has been cultivated for a time. In abandoned clearings the growth is exclusively pine.

East of the New Jersey Southern Railroad, in Monmouth county, the mixed belt is mostly oak and chestnut of all grades, from brush up to merchantable timber. The latter term is here used to include timber suitable for heavy railroad ties as well as larger trees suitable for sawing into dimension timber. In the Hominy hills, south of Colt's Neck, it is mostly pine, little of merchantable size. Westward from Farmingdale to Charleston Springs it is quite evenly mixed, the merchantable timber being confined to the vicinity of the highway from Lakewood to Freehold. From Charleston Springs to Hornerstown the line between pine and oak is quite sharply drawn, the pine being generally small and the oak of merchantable size. Indeed, the heaviest oak timber seen was in this vicinity. Proceeding southwesterly, the mixed belt retreats eastward to Collier's Mills, and the oak lands west are, as usual, well cleared.

Southwesterly from Collier's Mills, beyond Brindletown, pine predominates in the mixed belt and is of larger size, about one-half merchantable. Thence to New Lisbon it is more evenly mixed, but of smaller size, brush and light timber.

A good deal of land has been cleared just west of Asbury Park, but thence to New Lisbon there has been practically no clearing during the last fifteen years. Thence to Clayton there are a few clearings in and near the mixed belt, but south from Clayton, to Elmer, they are more numerous, and south of Elmer a good deal of territory has been cleared and brought under cultivation, especially around Rosenhayn, between Bridgeton and Millville, and east of Fairton.

Continuing from New Lisbon southwesterly, we find very little merchantable timber. Southeast from Medford, at Indian Mills and Tabernacle, there is a notable southeasterly encroachment of the oak and clearings, upon the pine belt. The mixed timber here has been cut very close, and what remains is mostly brush. It is little better anywhere southwest as far as Williamstown. Oak brush predominates throughout, accompanied by much small timber, and especially just south of Clementon. The general absence of good timber near the clearings here is probably attributable to close cutting for firewood and other local uses. The same conditions obtain near Elmer, Bridgeton and eastward, and especially around Rosenhayn. Wherever there is much clearing most of the older timber has been cut out, leaving brush from two to fifteen feet high.

From Williamstown to Elmer, however, there is much better timber in the mixed belt, especially to the northeast of a line joining these two places, oak prevails, and there is a fair proportion of merchantable timber. About Janvier there is the same severe cutting that has been noted above.

Southeast of Alloway, in Salem county, and considerably to the westward of the general limit of coniferous forests, there is an isolated tract of timber well mixed with coniferous trees, although oak preponderates. There is a fair proportion of merchantable timber here, although it is not so good as the exclusively deciduous timber which surrounds it, the latter being scattered over a highly cultivated country, in small groves and hedgerows.

Generally, in the foregoing description, we have used the term "oak" as synonymous with "deciduous." No real error can result from this, for it is true that oak largely outnumbers all other kinds in the deciduous forest. Chestnut occurs also, however, well scattered throughout, from Asbury Park to Delaware bay.

A plantation of grafted chestnut trees was observed in Camden county, just south of Point Pleasant and about three miles southeast of Spring Mills. Among the coniferous trees a few scattering white pines were noted between Asbury Park and New Egypt.

Generally speaking, however, the coniferous trees consisted of white cedar in the swamps and two varieties of pine on the upland; viz., the common pitch pine (*P. rigida*) prevailing everywhere, and the hemlock pine (*P. virginiana*) which was first observed, when going southwest along the pine border, at a point east of Pemberton; also scattering trees were seen about Tabernacle and Indian Mills. At Cedar Grove, on the Cohansey, this species became more numerous, and between Bridgeton and Millville nearly all of the pines seen were of this kind.

It will be noted that the map Plate III indicates Maurice river as the western limit of the exclusively coniferous forest in

Cumberland county. Not only is there a liberal mixture of deciduous trees west of this limit, but new clearings are more numerous and *P. virginiana* prevails instead of *P. rigida.*

An inquiry was begun to determine the extent of clearing within the pine belt in order to establish present tendencies. A careful survey of the clearings was made when the topographic survey was executed. In the pine belt this was from 1883 to 1886, and most of the work was done in 1884 and 1885. A re-survey at this time, therefore, will show the extent of clearing which has been done in the interval. Such a re-survey has been made at Hammonton, and a map showing the results has been prepared. It shows that the forest area has been very materially diminished. The same is true of most of the country along the New Jersey Southern Railroad all the way from Hammonton to Bridgeton, especially at Carmel, Vineland and Rosenhayn. Along the lines of the Camden and Atlantic, and Atlantic City railroads, from Hammonton to the coast, the same conditions prevail. Other centers of clearing are Richland and Woodbine. Most of the clearing is south of Mullica river—there is little or none north. A few clearings have been allowed to grow up again, but not enough to appreciably affect the tendency to increase the cleared land.

If present tendencies continue it seems plain that most of the land west of the limit of exclusively coniferous forest will be cleared up, or at least the forest will be divided up into small parcels.

Within the pine belt there will be a broad belt of cleared land extending from Hammonton to Absecon, another along the New Jersey Southern Railroad, southwest of Hammonton, and the extension of the large cleared area at Vineland and southerly to Woodbine will leave the pines divided into two tracts, the one lying in the Great Egg Harbor water-shed and the other north of Mullica river, extending to Lakewood. Within the limits of these areas, there is no observable tendency to extensive clearing. The forest is almost unbroken. It will be observed that these are also the tracts where the severest fires rage at present. It may be suggested that these are proper fields for something like systematic forestry, or at least for the inauguration of permanent measures to prevent fires. The remainder of the pine district is gradually but very steadily being broken up into small parcels by clearings, in such a way that fires will, in time, cease to be of very great importance. The tendency to clear up and bring under cultivation the better soils of the pine belt must be regarded as fortunate from every point of view. These better soils will produce more under cultivation than they possibly could in forest, and the breaking-up of this great belt of timber into sections will make it easier to deal with fires. There is an unfortunate prevalence of fires from carelessness about the clearings, but there seems to be existing legislation enough to deal with this question if the laws are enforced.

The importance of preserving some belts of timber throughout this ground that is being cleared up should be emphasized, however. They will be very valuable as wind-breaks, and it is quite possible that there will be a material change in the mildness of the climate of this section unless a reasonable amount of timber is preserved. The importance of leaving a good belt of timber along the streams is especially great. This needs to be done, especially in the case of the Great Egg Harbor and Maurice rivers, as it is on these water-sheds that most of the clearing is being done. The better soils here are usually on the higher ground, so that there should be little opposition to preserving the forests near the streams. These streams are now developed to an important extent for water power, and are likely to be still further developed in this direction. They have also a possible future value for water-supply, and the preservation of such bordering belts of timber would be a valuable safeguard in maintaining their purity. At least 75 per cent. of their water-sheds can be cleared and brought under cultivation without seriously endangering the streams, because of peculiarities which were pointed out in the Report on Water-Supply. The primary reason is that the rain falling upon the sand and gravel soil sinks at once into the ground and thence finds its way gradually to the stream lines. To appreciate the great difference in this respect from the red sandstone or Highlands district of northern New Jersey it is only necessary to compare the topographical maps of the two sections. In the north there will be observed a very large number of small tributaries, and generally one cannot go far in any direction without coming to a running brook, but in the pine belt there are quite large areas of the higher ground with no visible streams.

FIRES IN THE PINE FOREST.

We have noted previously that some damage is done by fires in the deciduous forest. This damage is confined principally to Kittatinny, Bearfort, Green Pond and Copperas mountains and the extreme northern Highlands. The fires in the deciduous forests are usually confined to small areas. In the pine forests of Southern New Jersey, however, extensive fires occur every summer. Any one who has witnessed a fire under full headway in this country must have been impressed with its grandeur, its irresistible fury and its disastrous effects. A few notes of remarkable fires are at hand. In 1866 a fire burned over 10,000 acres, extending seven miles inland from Tuckerton and West Creek. In 1870 and 1871 nearly the whole wooded portion of Bass River township, Burlington county, was burned over. In 1871 two fires in Ocean county burned over 30,000 acres. In 1872 a fire burned over from 15 to 20 square miles, worth before the fire from $10 to $30 per acre, and after from $2 to $4. In a paper on forest fires, by Mr. Charles E. Elmer, in the Report of State Board of Agriculture for 1874, he says of the year 1872: "To assume that 100,000 acres have been burned over, at a money loss in timber of $1,000,000, would surely be within the bounds of truth." From the census of 1880 we have for that year an area burned over of 71,074 acres, with an estimated loss of $252,240, which is certainly a very moderate estimate, and can scarcely include any allowance for loss of cedar swamps. In 1885, when the topographic survey was in progress, some very large fires occurred in the pine district, and the areas covered were noted by the topographers. One burned over an area of 60 square miles, near Atsion, in Burlington county; another, near Friendship, in the same county, covered 10 square miles, and another, in Ocean county, burned over not less than 75 square miles north of Barnegat. The total of these three fires is, therefore, 145 square miles, but several other fires occurred farther south in the State, the extent of which was not observed. It may be safely estimated that the whole area burned over that year reached 200 square miles, or 128,000 acres. A large amount of cedar swamp was destroyed by these fires, and $10 per acre would not more than cover the direct damage to timber, making the loss for the year $1,128,000, nearly equal to the total value of the annual lumber production of the State.

In 1895 Mr. Gifford reported 49 fires in this district, covering about 60,000 acres, and he estimated the average damage at $10 per acre, or $600,000 for the year. Indeed it seems that the average loss for many years past must have been in excess of this figure, and it would appear to closely approximate if not to exceed the yearly increase of value due to the growth of the pine forest. The loss is much more than the mere value of the wood. The soil is so impoverished by these periodical burnings, which deprive it of all vegetable matter, that those areas most subject to fires are becoming incapable of producing timber. Considerable damage is also done to cranberry bogs, cedar swamps and other improved property.

As to the causes of these fires, it would seem from statistics which have been gathered that approximately one-half are due to sparks from locomotives, about ten per cent. are incendiary in origin and the remaining 40 per cent. are accidental, arising largely from the carelessness of hunters, charcoal burners and persons engaged in clearing land for cultivation.

In the following 22 pages Mr. Gifford Pinchot gives the results of some careful studies which he has made, first as to the effect of forest fires in general, and next as to the specific effects upon the wood production of our pine forests.

Incidentally Mr. Pinchot has given us in these pages a fair representation of the present physical condition of much of the pine belt.

The Effects of Fire.

The harm that forest fires do may be classified as follows: 1st, damage to the standing timber; 2d, destruction of young growth; 3d, destruction of the forest floor; 4th, depreciation in the value of forest property; 5th, encouragement of theft and disregard of the rights of property, and discouragement of thrift and foresight among the people where fires occur; 6th, general impoverishment and degeneration of the regions where they are common.

DAMAGE TO STANDING TREES.

The damage to the standing timber is dependent on the kinds of trees in the forest, on the character of the latter, and on the time of the year when the fire burns. Young hardwoods suffer severely, but are often comparatively prompt in recovery. Pine forest is the prevailing type in South Jersey, and its relation to forest fires is of special interest. One of the distinguishing characteristics of the Pitch Pine is its ability to resist fire and to recover after severe injury. The Shortleaf Pine is also able to withstand severe fires, but its recuperative capacity is much less than that of the Pitch Pine. In each case the trunk is covered with a thick, corky bark, which is often burned till it is charred without apparent injury to the living parts of the tree. The outer bark scales off after a time, and the signs of fire disappear, except near the ground. In old Pine forests a light surface-fire usually does but little damage to the standing timber. Sometimes, however, if the forest is dense and there is a heavy matting of litter on the ground, the fire burns so fiercely that the trunks of the trees are seriously damaged, and, in the case of small timber, the trees may be killed. The same is true where the ground is covered with underbrush, which becomes dry and burns with intense heat. If the fire runs over the ground in spring before the sap begins to move, the damage is much less than after the season of vegetaion has begun. Decay frequently creeps in at the butt of severely burned timber.

EFFECT ON CEDAR SWAMPS.

White Cedar is extremely sensitive to fire and is easily killed, especially if the crown is affected. As a rule, however, Cedar swamps will not burn except in the early summer, when it is very dry, and often they will not burn even then. Wet swamps burn only in extraordinarily dry years, or when an unusually hot fire is driven through the trees by a strong wind. The trees on the edges of swamps, however, are frequently killed before the fire is stopped by the damp sphagnum moss. Sometimes the larger trees are not killed outright, but die gradually, beginning in the tops.

INJURY TO YOUNG GROWTH.

The larger hardwood trees resist fires admirably, and are killed only in the case of very severe fires. Young growth is often killed outright. All young trees are more sensitive to fire than larger ones, because the bark is thin and delicate, and also because the branches being low what is a surface-fire is to them a crown-fire, killing their tender shoots. Young Pitch Pine, however, withstands remarkably severe burning. Frequently surface-fires burn up to the crowns of small Pitch Pine, scorching the lower branches, but leaving most of the crown intact, and with it the life of the tree.

INJURY TO THE SOIL.

One injurious effect of forest fires which is apt to be neglected or even disputed is that which results from the destruction of the layer of vegetable waste and mold which is always found on the ground in undisturbed forests. This forest floor, as it is called, is made up of two parts: 1st, the upper wholly or partially decayed mass of leaves, twigs, and other vegetable material, called litter; and 2d, the thick, brownish, crumbly mass of real

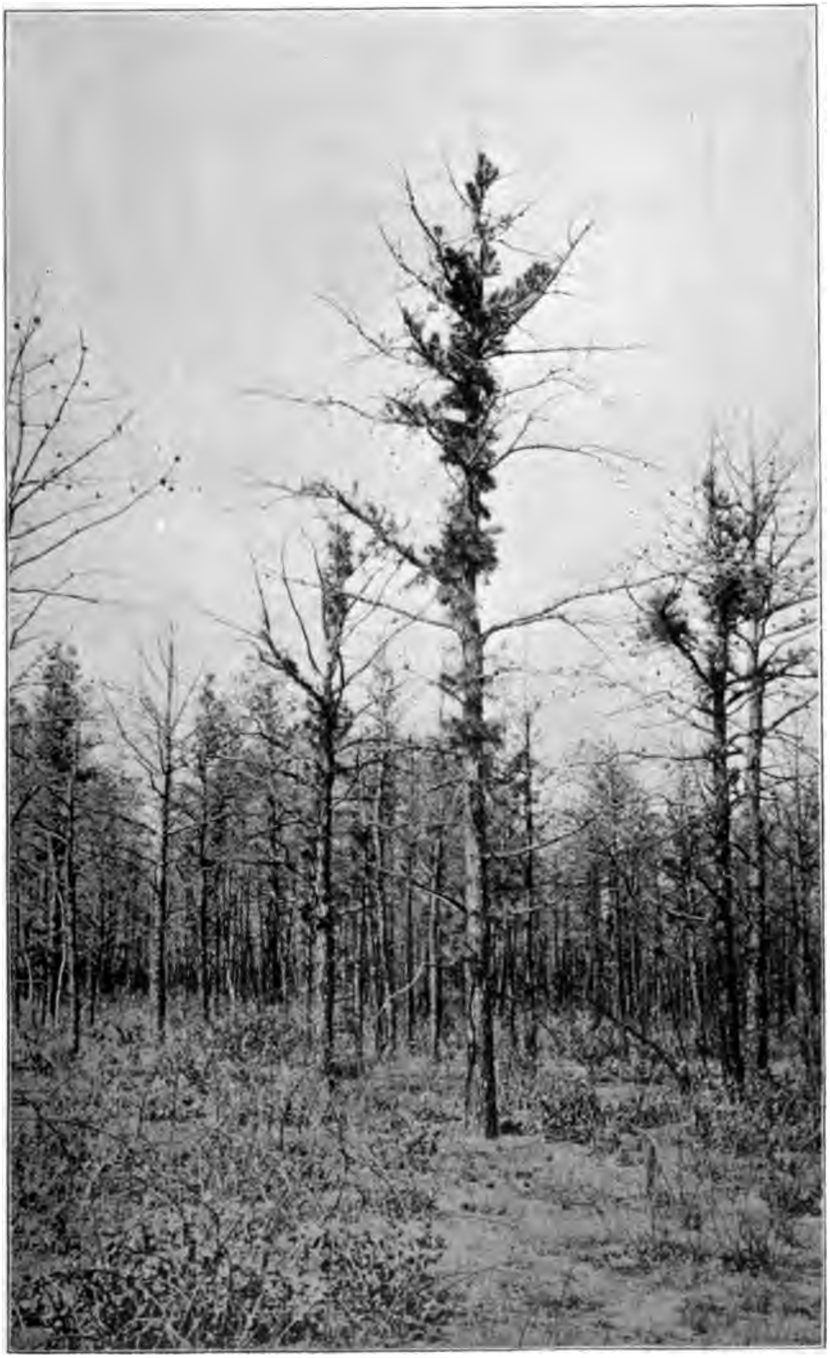


Plate No. IV.—Pitch Pine sprouting in the crown, after a fire which killed all the leaves, Ocean county.

humus, which finally is intimately mixed with the mineral soil. In New Jersey the upper layer of litter, which becomes exceedingly dry and burns rapidly, is generally looked upon as a positive evil, a danger to the welfare of the forest. This has led many owners of forest property to burn their land every spring before the dry season commences, and thus destroy the litter. Fires are in this way prevented from burning over the land later in the season and injuring the timber. Many people believe that this is the only way to protect their land from fire. As long as there is no organized fire service, this annual burning of the land and the consequent deterioration of the forest is certainly better than the destruction of valuable timber. If, however, the danger from forest fires can be reduced, which is shown elsewhere to be entirely possible, this annual burning becomes unnecessary. That it should cease is extremely desirable in view of the fact that in the majority of cases it is an actual injury to the forest.

An occasional light surface-fire can do comparatively little harm to the forest aside from the injury to young growth, for only the upper layer of dried leaves is burned and the lower, more valuable humus remains. Severe fires destroy the whole of the forest floor, and a considerable number of years must pass before it can be formed again. Continual burning, if it does not actually destroy the layer of humus, prevents new humus from forming, and what is left finally becomes disintegrated, and the same result follows as though it were destroyed at once. Whatever may be said of individual fires, their effect as a whole in South Jersey is simply disastrous.

On the loose, porous, sandy soil of southern New Jersey whatever tends to prevent the drying-out of the surface is valuable, for without moisture in the soil all other factors are of little consequence. According to German authorities, humus formed under conifers is capable of holding four or five times its own weight of water without losing a single drop, and it has besides a remarkable power of absorbing watery vapor from the air. A layer of humus is a powerful factor in preventing evaporation, and in New Jersey this drying-out of the soil is one of the most serious effects of the removing of the forest cover. Prof. Ebermayer, of the University of Munich, has established by actual experiments that a forest soil with a good layer of humus will lose two and one-half times less water by evaporation than forest soil where the humus is wanting.

Humus, by mingling intimately with the mineral soil, adds to it a proper consistency; it makes binding soils more porous, and loose soils more tenacious. It moderates the extremes of temperature in the soil, and this is of great importance in sandy regions. Not only does humus possess the power of absorbing water, vapor and heat, but it has the ability to absorb some of the most important food materials of plants as well. Thus nitrates, phosphates, ammonia, &c., are held in solution ready for the use of the plants. Without humus many of the most important mineral materials would be washed away, especially from the loose soil of South Jersey.

Humus acts further as a reservoir from which food materials may be obtained, and by means of which they may be made ready for the use of the tree in growth. The final products of the decomposition of the humus are the mineral ashes, carbonic acid gas, and water. Through the ashes of the leaves, twigs, etc., a large amount of the most important materials used in the manufacture of wood are returned to the soil, and that in the most usable form. The carbonic acid gas acts powerfully toward the disintegration of the soil and in making the food constituents soluble, and in many sandy soils the value of its presence is very great. Thus the humus is really a manure to the forest.

If this layer of vegetable mold is destroyed the soil is impoverished at once. It loses one of the most powerful agents in its decomposition, loses its activity also, and finally becomes practically dead. In Europe it has been long recognized that the presence of humus is very beneficial to the forest, and its absence disastrous. This has led to laws forbidding the removal of the litter by peasants. The experience of the Germans has taught them that when the litter is continually taken away the forest becomes more and more open, the sun's rays and a freer circulation of air are admitted, the humus disappears, the soil dries out and the trees become short, scrubby, and short-lived. Further, the soil eventually becomes so impoverished that trees which were at first produced are replaced by less fastidious and usually less valuable species. Thus in many parts of Germany, where formerly hardwoods thrived, now Pine is the only species that can be profitably grown.

It is not necessary, however, to go to Germany to see the effect of the destruction of humus on the welfare of the forest. Abundant illustration is found in South Jersey. The conditions are somewhat different from those in Europe, for there the litter is removed from the forest by the peasants, while here it is burned on the ground. The mineral substances remain, but when the humus is destroyed they are probably, for the most part, washed away in the deep porous sand.

The most serious injury from fire in New Jersey is its effect on the reproduction of the forest. Hope is frequently expressed for the future of the Pine in New Jersey because the Pitch Pine springs up so persistently after fire. It is true that throughout the fire-scarred tracts small Pine appears in great profusion after fires, but a close examination reveals the fact that in many cases these are not seedlings, but sprouts from the stools of the trees which were apparently killed. It is true that seeds germinate quickly on the sandy soils because of the capacity of the soil to become readily heated. But where the bare soil is exposed to the scorching sun and wind, as on large stretches of land in the coastal regions of South Jersey, it is difficult for seedlings to survive.

MORAL EFFECT OF FIRES ON POPULATION.

It is obvious that where the forest is constantly exposed to fire and there is no adequate protection, its value must be greatly depreciated. The result is that the timber is often cut before its maturity. Landowners believe that with proper protection against fire the value of forest property will be greatly increased.

The fires have been so abundant that the people have come to look upon them as inevitable, and there is a deplorable lack of real interest among land-owners in regard to any attempt to introduce State protection. Large tracts of land are owned by non-resident capitalists, and timber-stealing is very common, especially after fires. When the timber is killed many persons consider it better to use the dead trees for cordwood than to allow them to rot on the ground, and they cut such timber on tracts of land to which they have no right. There is no doubt that forest fires encourage a spirit of lawlessness and a disregard of property rights.

Effect of Fire on the Forest Production.

All who are familiar with the conditions of South Jersey know, from their own observation or from what has been written, that forest fires are very common and enormously harmful. But the extent of the damage is not often fully comprehended, for the devastated lands are compared with the forests which are now in existence, and not with those which grew originally, and which might still be flourishing if the land had been protected. It was the purpose in this investigation to determine by actual measurements the condition of the forest on burned areas, and to compare it with forest which had been protected from fire. A large number of sample plots, mostly of one acre each, were surveyed in different sections, the trees carefully measured, and notes were made of the height, age, density, condition, etc. From these valuation surveys, the results of which are summarized below, an accurate picture of the forest under different conditions can be obtained, and the deterioration of the forest can be traced step by step from the heavy timber 200 years old to the barren wastes, with scattered fire-scarred Pine sprouts and scrub Oaks, which are so abundant in South Jersey.

THE ORIGINAL TIMBER.

The greater part of southeastern New Jersey was originally covered with a heavy growth of Pine. The poorer soils were probably occupied by Pitch Pine, the medium and better soils by Shortleaf Pine and hardwoods and the deep swamps by Cedar.

From a study of scattered old timber, it is estimated that the original mature Pine forest yielded on an average from five to ten thousand board feet per acre. The timber was about 150 to 200 years old and 15 to 20 inches in diameter, with occasional trees as large as 24, or even 30 inches. The average height of the old timber was 65 to 70, and the maximum 80 to 90 feet. The forest was open, with comparatively little undergrowth. It probably had a density of 0.6 to 0.8, if we consider that of a fully stocked stand to be 1.0. The seventeen sample plots in the summary, on page 99, show the condition of the original forest.

SECOND GROWTH.

When this timber was cut off, a second growth of Oak and Pine took its place on the better soils, while on poor soil Pitch Pine was the principal species. The second growth was chiefly of seedling origin.

From the time of the first heavy cutting, fires began to play an increasingly important part in the development of the forest. When the young trees were killed back by cutting or burning, the stumps, both of the hardwoods and the Pitch Pine, sent up sprouts. Where the land was protected from fire, seedlings returned and a thrifty second growth resulted, but when fires continued to run the few seedlings which crept in were in turn killed back, and afterward sprouted again; many trees were entirely killed; the forest became thinner and thinner; the ground clothed itself with a dense growth of huckleberries, scrub Oaks and dry-land moss, or the soil was completely laid bare; and land which once produced heavy timber was made almost worthless. It requires but a glance at the surveys taken on badly burned land, *i. e.*, those of Table 3, to see, in the number of trees, the yield per acre, and the density, the deplorable condition of the forest.

CONCLUSIONS DERIVED FROM THE VALUATION SURVEYS.

For the acres in Table 3 the density averages 0.3, the number of trees per acre 133, and the yield 2.9 cords. From the study of second-growth timber which has not been burned, it is clear that the density would be 0.7 to 0.8 if the tract had been protected from fire. If we assume that the trees on the protected tract were sprouts there would be about three times as much wood per acre. If the trees were from the seed there would be, at forty years of age, on land fully stocked, about 1,200 trees and not less than 20 cords per acre, or about six times as much as is

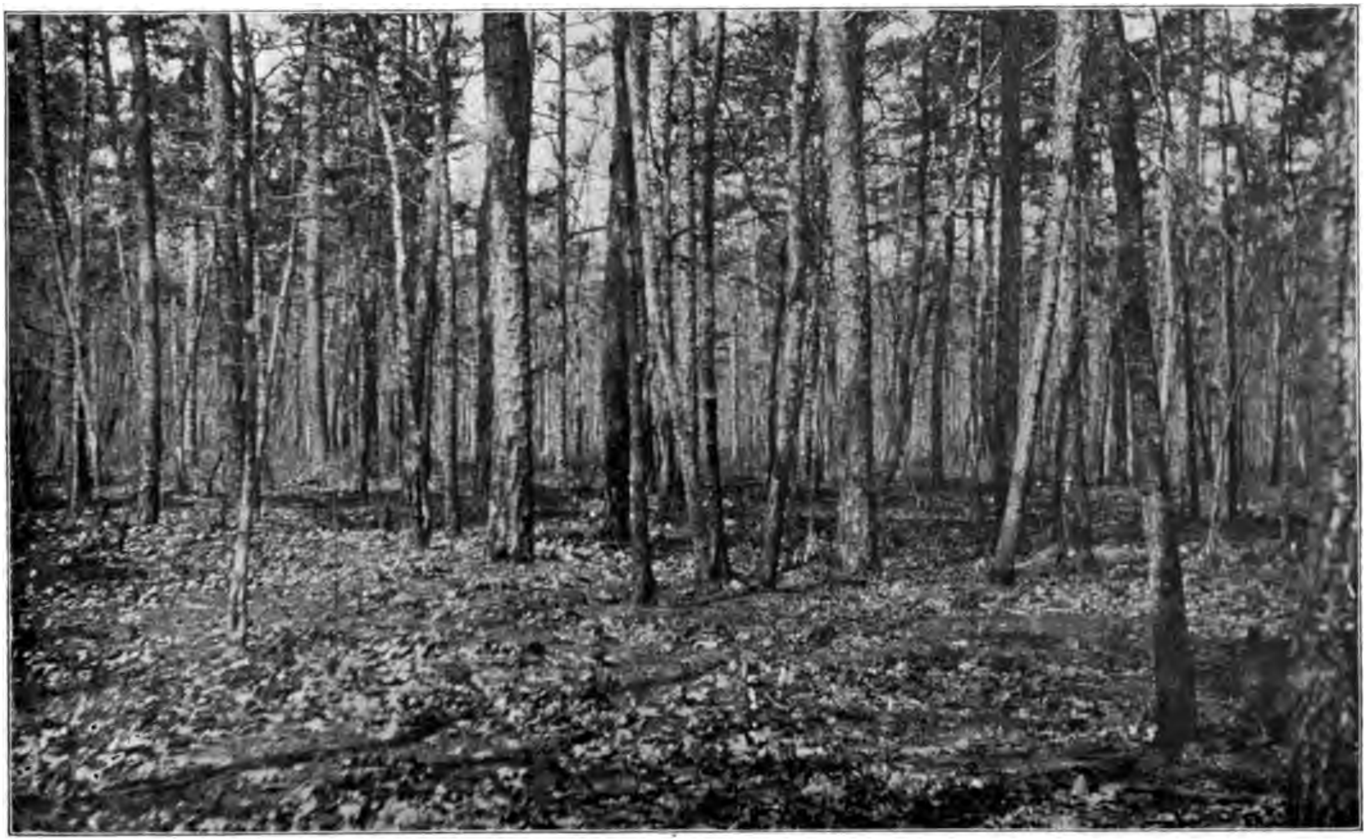


Plate No. V.—Original Pine Forest at New Lisbon.

now produced. Further, the timber now found is coarse and knotty and fit for nothing better than cordwood, while in dense stands the trees are straight and clear of knots.

The burned land represented by the acres in Table 3 is then producing about one-third of the volume it would if protected from fire, and about one-sixth of what it is capable of yielding under careful management, while in quality and price the wood is very much inferior to the product of a healthy forest on the same ground.

Summary of Forty-nine Valuation Surveys, Showing the Deterioration of the Forest Through the Effects of Fire.

Table 1.

ORIGINAL FOREST.

Plot No.	No. of trees per acre.	Average diameter. Inches.	Average diameter over 6 inches. Inches.	Average age. Years.	Yield per acre. Board Feet.	Density.
1	67	. . . .	13.9	100-200	10,170	0.7
2	70	. . .	14.0	" "	9,925	0.6
3	78	. . . .	13.0	" "	8,940	0.6
4	86	. . . .	12.7	" "	8,828	0.7
5	113	. . . .	10.0	" "	8,000	0.6
6	92	. . . .	12.0	" "	7,739	0.6
7	65	. . . .	13.0	" "	7,521	0.6
8	71	. . . .	12.4	" "	7,488	0.6
9	68	. . . .	12.5	" "	7,208	0.6
10	104	. . . .	11.2	" "	6,134	0.7
11	97	. . . .	10.2	" "	5,760	0.6
12	45	. . . .	13.1	" "	5,631	0.5
13	80	. . . .	10.1	" "	5,200	0.6
14	85	. . . .	11.0	" "	4,618	0.55
15	97	. . . .	10.7	" "	4,500	0.6
16	245	. . . .	9.0	" "	3,700	0.7
17	74	. . . .	10.4	" "	3,369	0.55
Average,	91	. . . .	11.7	. . . .	6,631	0.6

Table 2.

SECOND GROWTH ON LAND PROTECTED FROM FIRE.

Plot No.	No. of trees per acre.	Average diameter. Inches.	Average diameter over 6 in. Inches.	Average age. Years.	Yield per acre. Board Feet.	Yield per acre. Cords.	Density.	Remarks.
18	286	. . .	8.6	80	7,397	. .	1.0	Seedling second growth
19	323	. . .	8.9	80	7,604	. .	1.0	"
20	364	9.8	. . .	50	.	48	0.8	Chiefly from seed
21	482	6.6	. . .	40-60	. . .	34	0.7	"
22	573	5.2	. .	40-60	. . .	21	0.8	"
23	279	6.6	. . .	55 (est)	. . .	20	0.7	Seedling second growth.
24	1,088	4.4	. . .	40 (est.)	. . .	20	0.9	"
25	724	4.8	. . .	40-60	. . .	20	0.95	Chiefly from seed
26	532	5.3	. . .	40-60	. . .	18	0.75	"
27	559	4.8	. . .	40-60	. . .	16	0.8	"
28	410	5.3	. . .	40-60	. . .	14	0.7	"
29	988	3.7	. . .	35-40	. . .	13	1.0	Sprouts.
30	521	3.9		35-40	. . .	7	0.8	"
Average	548	5.5	8.8	. . . . .	7,500	21	0.8	

Table 3.

SECOND GROWTH ON LAND BADLY BURNED.

Plot No.	No. of trees per acre.	Average diameter. Inches.	Average age. Years.	Yield per acre. Cords.	Density.	Remarks.
31	105	7.0	30-40 (est.)	7.5	0.5	Chiefly sprouts.
32	339	4.7	. .	7	0.6	"
33	98	6.4	30-40 (est)	5	0.2	"
34	189	4.8	" "	4.2	0.3	"
35	191	4.8	" "	4.2	0.2	"
36	94	5.7	" "	3.1	0.2	"
37	121	4.9	" "	2.8	0.2	"
38	221	3.1	20-30 "	2.7	0.1	"
39	200	3.6	30-40 "	2.6	0.4	"
40	73	5.5	25-30 "	2.3	0.1	"
41	177	3.4	20-30 "	2.2	0.1	"
42	118	4.4	30-40 "	2.2	0.4	"
43	114	4.4	" "	2.1	0.3	"
44	191	2.9	" "	2.1	0.2	"
45	90	4.5	" "	1.7	0.2	"
46	135	3.2	20-30 "	1.6	0.3	"
47	42	5.5	30-40 "	1.3	0.2	"
48	26	4.2	30 "	0.4	0.1	"
49	14	5.5	" "	0.5	0.1	"
Average	133	4.8	. . . . . .	2.9	0.3	

DESCRIPTIONS OF REPRESENTATIVE AREAS.

The following detailed descriptions of the measurements taken in different parts of South Jersey contain the essential facts from which the conclusions in the preceding sections were drawn. They illustrate the methods used in the investigation and give some indication of the localities studied and of the amount of labor involved.

Original Forest at Winslow.

A satisfactory understanding of the loss occasioned by forest fires in South Jersey presupposed a knowledge of what the land is capable of producing when uninjured by burning. To acquire such knowledge was not easy.

There are comparatively few places where original pine can still be found, and in these the soil is apparently better than on the fire-scarred areas now covered with straggling, scrubby second growth. These places may, however, be used to illustrate the original conditions, for the soil on areas now fire-scarred was doubtless more productive when covered with a rich layer of forest litter than it is now; and while the original trees over the greater part of South Jersey were probably for the most part Pitch Pine, the yield per acre probably did not fall far short of that of the Shortleaf (locally called Yellow) Pine now found on the areas studied, the fertility of which was somewhat above the average.

One plot of old timber situated near Winslow is owned by Mr. J. H. Rosenthal, of Philadelphia. The large Pine was being cut for the market while this plot was being studied, and the measurements were taken as the trees were sawed into logs. In this forest the Yellow Pine predominates, but there are considerable numbers of Pitch Pine as well. The Pine occurs both in patches and scattered over the area, and is associated with small Oaks and a few larger ones. The trees reach a diameter of two and a height of eighty-five feet. The larger Oaks, White and Chestnut, in some cases reach a diameter of thirty inches, while among the smaller trees Black and Post Oaks are found. The soil is a white sand, with a slight admixture of loam on the better portions. In this forest there were measured twelve sample acres, a summary of which is given in Table 5, below. The following sample acre is given in full and furnishes a very good mental picture of the average conditions in this forest.

Table 4.

One Acre Measured Near Winslow, New Jersey.

Diameter, breast high.	Pine including stumps.	White Oak.	Black Oak.	Chestnut Oak.	Post Oak.	Hickory.
3 Inches	1	26	7	. .	. .	2
4 "	2	12	14	4	. .	. .
5 "	2	10	15	2	. .	. .
6 "	2	8	21	2	. .	1
7 "	6	4	12	1	. .	. .
8 "	2	6	3	1	. .	. .
9 "	4	6	1	1	. .	. .
10 "	4	4	1	2	1	. .
11 "	4	. .	1	2	. .	. .
12 "	14	1	. .	. .	. .	. .
13 "	5	1	. .	. .	. .	. .
14 "	8	1	. .	. .	. .	. .
15 "	5	. .	. .	. .	. .	1
16 "	2	. .	. .	. .	. .	. .
17 "	6	. .	. .	. .	. .	. .
18 "	. .	. .	. .	. .	. .	. .
19 "	1	. .	. .	. .	. .	. .
20 "	. .	. .	. .	. .	. .	. .
	68	79	75	15	1	4

Average height of Pine, 68 feet. Diameter of the average tree over ten inches, 13.7 inches. Total volume, 2,127 cubic feet. Total merchantable volume over ten inches, 7,208 board feet. Yield of hardwoods, 7.0 cords (est.).

Soil, dry sand. Flat. Undergrowth composed of young Oaks and a few Pine seedlings. Humus rather poor. Density, 0.6 of the normal.

The following table gives a summary of the twelve acres studied at Winslow. The merchantable trees are of various ages, from 120 to 200 years old. It will be seen that there are on an average about 45-50 trees per acre over 10 inches, with an average yield of about 7,000 board feet.

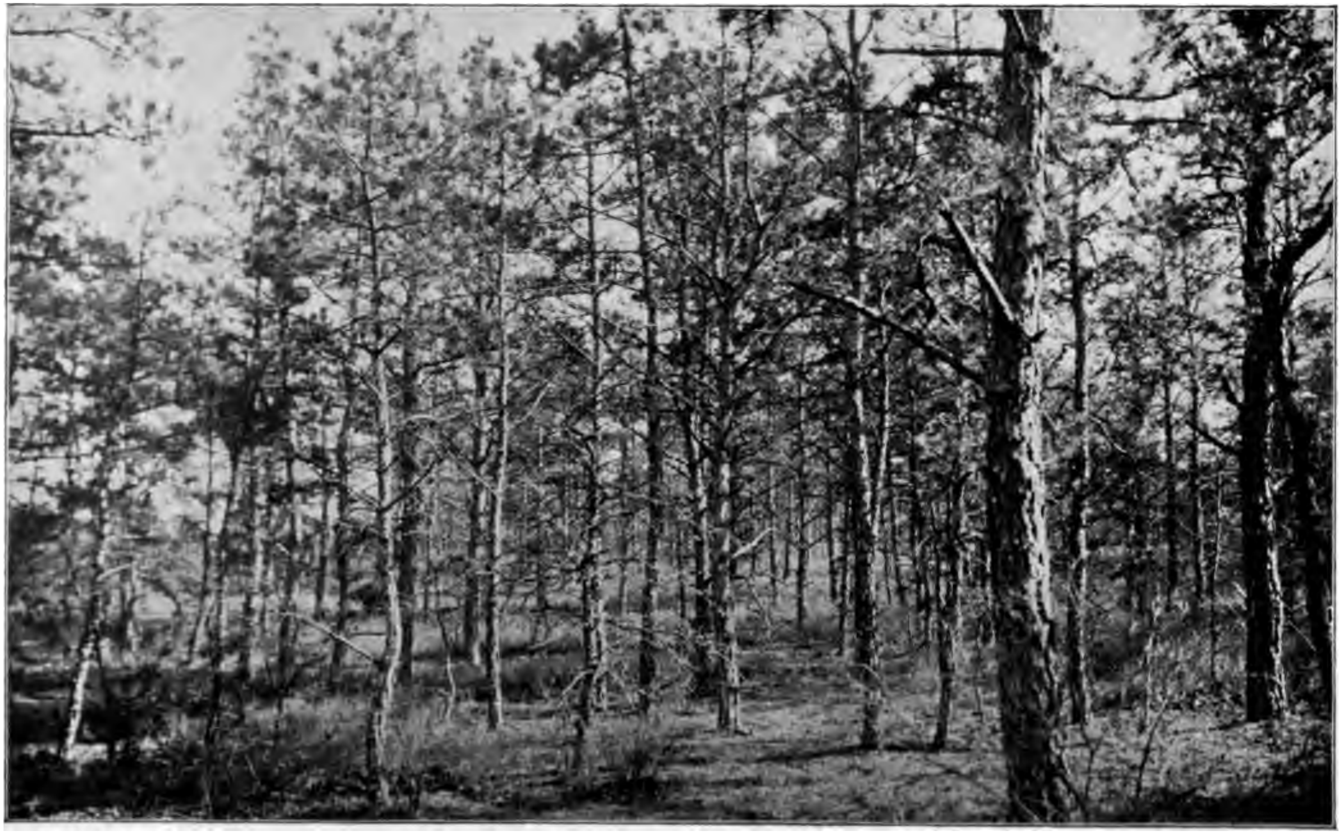


Plate No. VI.—Second-growth Pitch Pine, Ocean county.

Table 5.

Summary of Measurements on Twelve Acres of Old Pine at Winslow, New Jersey.

				PINE.							HARDWOODS.		
Plot number.	Number of trees.	Number of trees over six inches.	Average diameter breast high.	Number of trees over ten inches.	Average diameter breast high.	Maximum diameter breast high.	Average height.	Total volume over six inches.	Merchantable volume over ten inches.	Number of trees.	Average diameter breast high.	Cords (estimated).
			Inches.		Inches	Inches.	Feet.	Cu. ft.	Bd. ft.		Inches.	
1	67	66	13.9	34	14.4	22	69.1	2,882	10,170	140	5.9	6.5
2	70	65	14.0	51	16.2	18	68.8	2,917	9,925	96	6.2	5.5
3	78	72	13.0	56	14.8	18	66.9	2,812	8 940	137	5.6	5.5
4	86	74	12.7	56	13.9	20	69.7	2,548	8,828	161	5.9	7.5
6	92	78	12.0	55	13 4	18	68.1	2 557	7,739	183	6.9	13.5
7	65	60	13.0	46	14.3	21	67.5	2,228	7,521	121	6.8	8:5
8	71	69	12.4	54	13.5	19	66.3	2,388	7,488	120	7.0	9.0
9	68	63	12.5	49	13.1	19	68.1	2,127	7,208	174	5.7	7.5
10	104	78	11.2	51	12.6	17	68.1	2,048	6,134	124	6.4	7.3
12	45	43	13.1	35	14.1	20	68.1	1,613	5,631	6	6.3	0.0
14	85	62	11.0	35	13.1	19	66.8	1,708	4,618	147	6.9	11.0
17	74	57	10.4	27	12.8	16	66.8	1,275	3,369	159	6.3	9.0

Original Forest at New Lisbon.

Another forest of old Pine was found at New Lisbon, on the estate of Mr. Black. Here, as at Winslow, the Pine was scattered in patches, mixed with oaks, and as before, the Shortleaf Pine predominated. The average yield of Pine on the five acres measured was about 5,500 board feet and the number of trees per acre over ten inches in diameter about fifty. The following sample acre will serve to illustrate the forest in this section. This plot is figured in Plate VII.

Table 6.

One Acre Measured in Old Pine Near New Lisbon, New Jersey.

Diameter breast high.	Pine, including stumps.	White Oak.	Black Oak.	Chestnut Oak.	Post Oak.
1 Inch	3	18	7	5	. .
2 Inches	1	18	13	19	2
3 "	8	13	13	24	. .
4 "	5	14	10	26	. .
5 "	2	7	10	24	1
6 "	5	13	10	6	. .
7 "	7	3	. .	8	1
8 "	2	1	3	. .	. .
9 "	6	1	. .	. .	. .
10 "	7	2	. .	. .	. .
11 "	5	1	. .	. .	. .
12 "	17	1	. .	. .	. .
13 "	7	. .	. .	. .	. .
14 "	4	. .	. .	. .	. .
15 "	6	1	. .	. .	. .
16 "	1	1	. .	. .	. .
17 "	. .	. .	. .	. .	. .
18 "	. .	. .	. .	. .	. .
19 "	2	. .	. .	. .	. .
	88	94	66	112	4

Average height, about 65 feet. Diameter of the average tree over ten inches, 12.8 inches. Yield of Pine over ten inches, 5 200 board feet; of small Pine, 1.1 cords; of Oaks, 3.5 cords Soil, dry white sand. Flat. Burned over every spring, and underbrush killed. Density, 0.6 of the normal.

Table 7.

Five Acres Studied at New Lisbon.

Plot No.	No. Pine including stumps.	No. Pine over 10 in.	Ave. Diam. breast high. Inches.	No. Pine under 10 in.	Ave. Diam. breast high. Inches.	Merch. Pine. Board feet.	Small Pine. Cords.	No. Oak.	Ave. Diam. breast high Inches.	Yield. Cords.
5	113	46	15.1	86	4.9	8,000	2.6	130	3.0	1.3
11	97	64	11.8	51	6.2	5,760	2.8	233	3.9	3.5
13	80	52	12.8	39	4.7	5,200	1.1	276	3.8	3.5
15	97	53	12	44	5.2	4,500	1.5	383	4.0	6.0
16	245	37	12	208	3.4	3,700	3.8	119	3.1	1.0

SECOND GROWTH.

When land of this character is cut over it is usually followed by a growth of hardwoods and Pine on the medium and better soils, and, on the areas less adapted to hardwoods, by Pitch Pine. Pine gradually creeps back on the areas which have come up to hardwoods and in many cases crowds them out. Often the Pine seeds an old field with good soil very abundantly, and a pure forest springs up. Such a patch was found nearly fully stocked at Winslow, and two acres are given in detail on pages 52 and 53 of the Annual Report for 1898. This forest is a nearly even-aged stand of Shortleaf (Yellow) and Pitch Pine, the former predominating, about eighty years old, and gives an admirable picture of what a normal stand of Pine can produce. A full discussion of the tract is found with the surveys. It is exceedingly interesting to compare this stand with the old forest at Winslow. It will be seen that the yield in board feet is just as large for trees over ten inches, and that the yield (over six inches) is about twice as large, while the trees are only about one-half as old.

Such stands as this are the great exception, for the reproduction of the forest has been left to take care of itself, the trees have been cut with no regard whatever to the next crop, and fires have swept over the ground repeatedly, destroying young growth and thinning the old timber, so that as a rule the second-growth forest is open and straggling. The soil is abundantly able, for the most part, to produce merchantable timber, in spite of repeated fires and bad cutting. These latter, and not the soil itself, are responsible for the present poor condition of the forest, which needs only protection and judicious cutting to regain its value in the end.

Second Growth at Whitings.

A number of acres of second growth studied near Whitings are exceedingly interesting, both as to their origin and their growth and development. The surveys given below were taken about two miles southeast of Whitings, on a private tract of about one thousand acres. The forest is a pole wood of high density, containing trees of two age classes, one about fifty to sixty, the other thirty to forty years old. The larger trees have every appearance of being of seedling origin. The smaller trees seem like sprouts, for they are crooked and contorted, and of very slow growth. There are, further, many small, twisted trees, thirty to fifty years old, and only one to two inches in diameter, which spread out in umbrella form at about six to eight feet from the ground. It is reasonably certain that these are stunted sprouts, which manage to live in the shade of the pole woods and grow only enough to maintain their existence.

The humus is deep and the soil a dry white sand. There has been no fire for many years, the tract having been successfully protected by careful watching.

The average height of the older class of trees is 45, of the younger 36 feet. The rate of growth for the older trees is one inch in diameter in fifteen years, of the smaller trees one inch in twenty years.

Although it is extremely difficult to determine definitely whether the older trees on this area are seedlings or sprouts, the conclusion arrived at from study here and elsewhere is that they are seedlings. The old stumps probably have a limited capacity for sprouting. It is the roots of the second and third growth and the succeeding generations that produce sprouts freely. The following sample acre will serve to illustrate the character of this second growth:

Table 8.

One Acre Measured Near Whitings, New Jersey.

Diameter breast high.	Pine.
1 Inch,	18
2 Inches,	30
3 "	44
4 "	43
5 "	76
6 "	80
7 "	30
8 "	40
9 "	21
10 "	17
11 "	9
12 "	2
	410

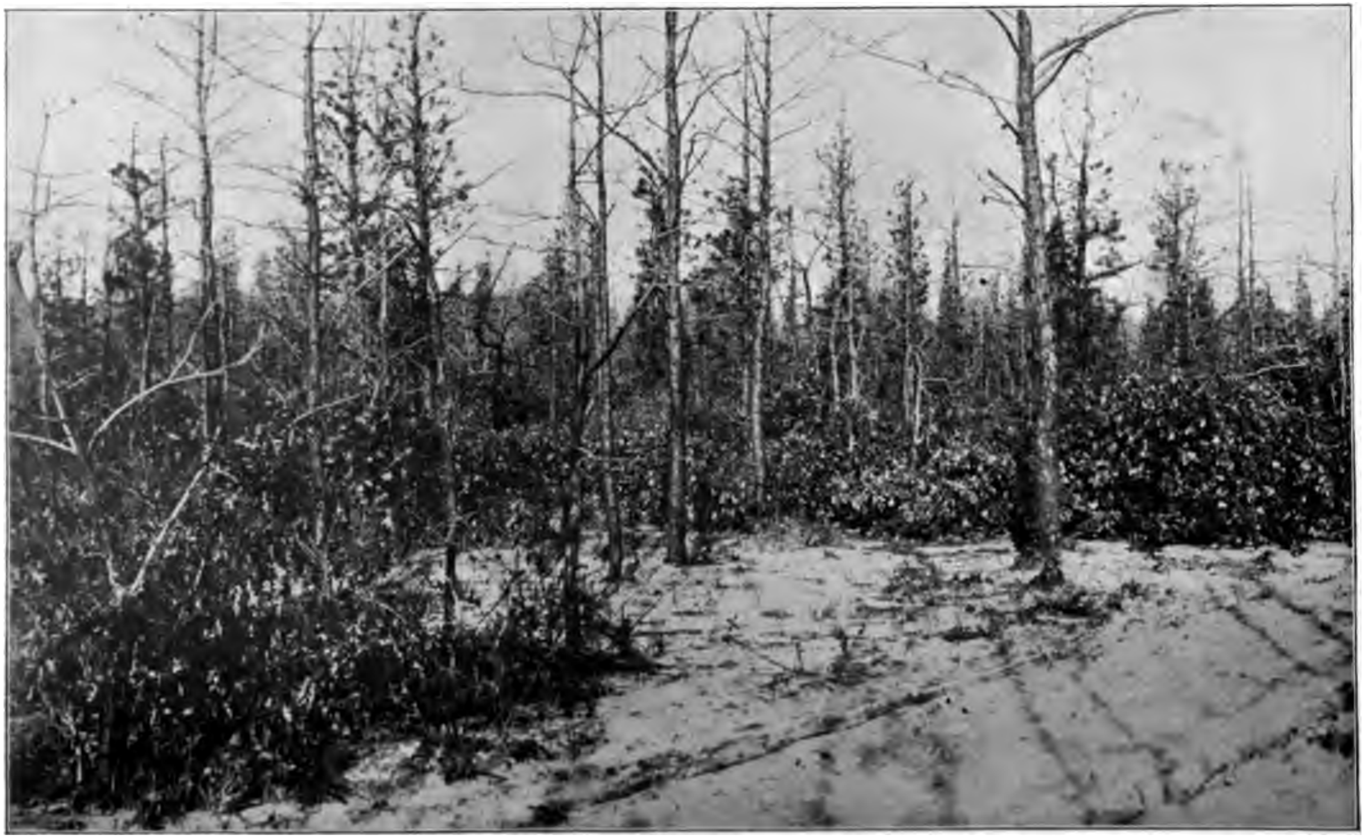


Plate No. VII.—Badly Burned Pine with Stunted Oak Sprouts underneath, Burlington county.

Yield of pine, 14.0 cords (est.). Average diameter, 5.3 inches. Soil, white sand. Slope, gentle to northwest. Undergrowth, Huckleberries and Ground Oak. Humus, deep. Density, 0.7 of the normal.

Table 9.

Six Surveys at Whitings, N. J.

Plot No.	No of Pine.	Area. Acres.	Average diameter breast high. Inches.	Maximum diameter breast high. Inches.	Yield. Cords.	Yield per acre. Cords.
21	241	½	6.6	11	17	34
22	573	1	5.2	13	21	21
25	362	½	4.8	11	10	20
26	266	½	5.3	12	9	18
27	559	1	4.8	12	16	16
28	410	1	5.3	12	14	14

Pine Sprouts at Whitings.

In discussing the question of sprout Pine growth it is instructive to study both verbal and visual pictures of an area which is surely of this origin. This forest is about one mile west of the preceding acre, and is probably of the same age as the smaller trees on that plot. The young pole-wood has a density nearly normal, and the soil is a dry white sand. There is an undergrowth of huckleberries and Scrub and Post Oaks, but the area has not been burned over and the humus is excellent.

Table 10.

One-quarter Acre of Pine Sprouts, 35 to 40 Years Old, Near Whitings, N. J.

Diameter.	No of trees.
2 Inches,	40
3 "	85
4 "	62
5 "	42
6 "	12
7 "	5
8 "	1
	247

The average age of the crop is 35 to 40 years; the average height, 24 feet; the average diameter, 3.7 inches. It is fair to ask why the growth is slow. The soil, it is true, is a dry sand, but similar soil has been observed to bear very much more rapidly growing trees. Fire has never touched the trees and there is a deep humus. The reason has already been given. The trees are twisted and crooked, and often with from two to five stems apparently from the same root, and the forest is composed of Pine sprouts. The yield of this area is estimated to be thirteen cords per acre.

Not far from this plot a small area was studied where the wood had been cut and stacked. The trees were not nearly so numerous, and fire had apparently run over the area at some time, though not of late. The stumps were measured on 0.3 of an acre.

Table 11.

Diameter on stump.	No. of trees.
2 Inches	27
3 "	50
4 "	47
5 "	17
6 "	17
7 "	9
8 "	1
	168

The stacked wood measured slightly over two cords, or about seven cords per acre. Six stumps were studied, and the age was found to be thirty-five to forty years on the stump.

The growth of an average stump was 0.6 inches in diameter in the last ten years, or at the rate of one inch in about seventeen years.

Second Growth After Fire.

The sample acres given above show what the original forest probably produced and what the second growth yields, whether of seedlings or sprouts, where the land has not been very severely burned. It remains to show the condition of land which has been repeatedly burned, and to trace the various stages of deterioration from the condition described above to the desolate stretches of sand-barrens in some sections of Ocean county.

The first stages of deterioration of the forest may be illustrated by the valuation survey which was taken near West Creek, Ocean county, New Jersey. The soil is a fine white sand, with a moderate layer of humus. The land has been burned a number of times, but the fire has been chiefly confined to the surface. The trees are very coarse and scrubby, and that while there is a fairly large number per acre, the diameters are small and the trees stand too far apart for good natural pruning to take place. The ground is covered with huckleberries and Scrub Oaks between the Pines. These trees are probably about thirty to forty years old. In a normal stand of this age there should be not less than nine hundred to one thousand stems per acre.

Table 12.

One Acre Measured in Second-Growth Pine Near West Creek, Ocean County, N. J.

Diameter.	No. of trees.
2 Inches,	22
3 "	56
4 "	88
5 "	72
6 "	60
7 "	33
8 "	8
	339

Number of Pine under two inches, 73.
Number of Oak under two inches, 389.
Average diameter of the Pine, 4.7 inches.
Yield of Pine estimated to be about seven cords.

The next stage in the decline of the forest is well illustrated by the valuation survey below, and by Plate VII. This survey was taken near Ongs Hat, Burlington county. The area has been burned many times, and the trees are scrubby and scattered. There is but little undergrowth, and almost no humus, and even Scrub Oaks find difficulty in growing. The number of trees is even less than before. The photograph is taken near Tuckerton, but shows the same stage in the deterioration of the forest as the valuation survey.

Table 13.

One Acre Measured in Second-Growth Pine Near Ongs Ha
Burlington County, New Jersey.

Diameter.	No. of trees.
2 Inches,	35
3 "	7
4 "	18
5 "	23
6 "	12
7 "	9
8 "	6
9 "	8
	118

Number of Pine under two inches, 108.
Number of Oak under two inches, 162.
Average diameter of the Pine, 3.7 inches.
Yield of Pine estimated to be about 1.6 cords.
Soil, gravelly sand. Flat. Density, 0.4.

Table 14.

Nine Sample Acres Showing a Still Further Advanced Stag
in the Deterioration of the Forest by Fire.

Plot No.	Pine over 2 inches in diameter.	Average diameter, breast high.	Maximum diameter, breast high.	No. of cords.	Pine under 2 inches in diameter.	No. of small oaks.	Density.	Locality.
		Inches.	Inches					
31	105	7.0	14	7.5	74	113	0.6	Ongs Hat.
33	98	6.4	13	5.0	. .	1	0.2	Ongs Hat.
34	189	4.8	8	4.2	68	208	0.5	Near East Plains
36	94	5.7	12	3.1	. .		0.2	Ongs Hat.
37	121	4.9	9	2.8	78	708	0.2	Near East Plains
39	200	3.6	9	2.6	77	34	0.4	Spring Hill.
43	114	4.4	8	2.1	139	274	0.3	Tuckerton
45	90	4.5	8	1.7	36	411	0.2	Near East Plains
47	41	5.5	10	1.3	1		0.2	Ongs Hat.

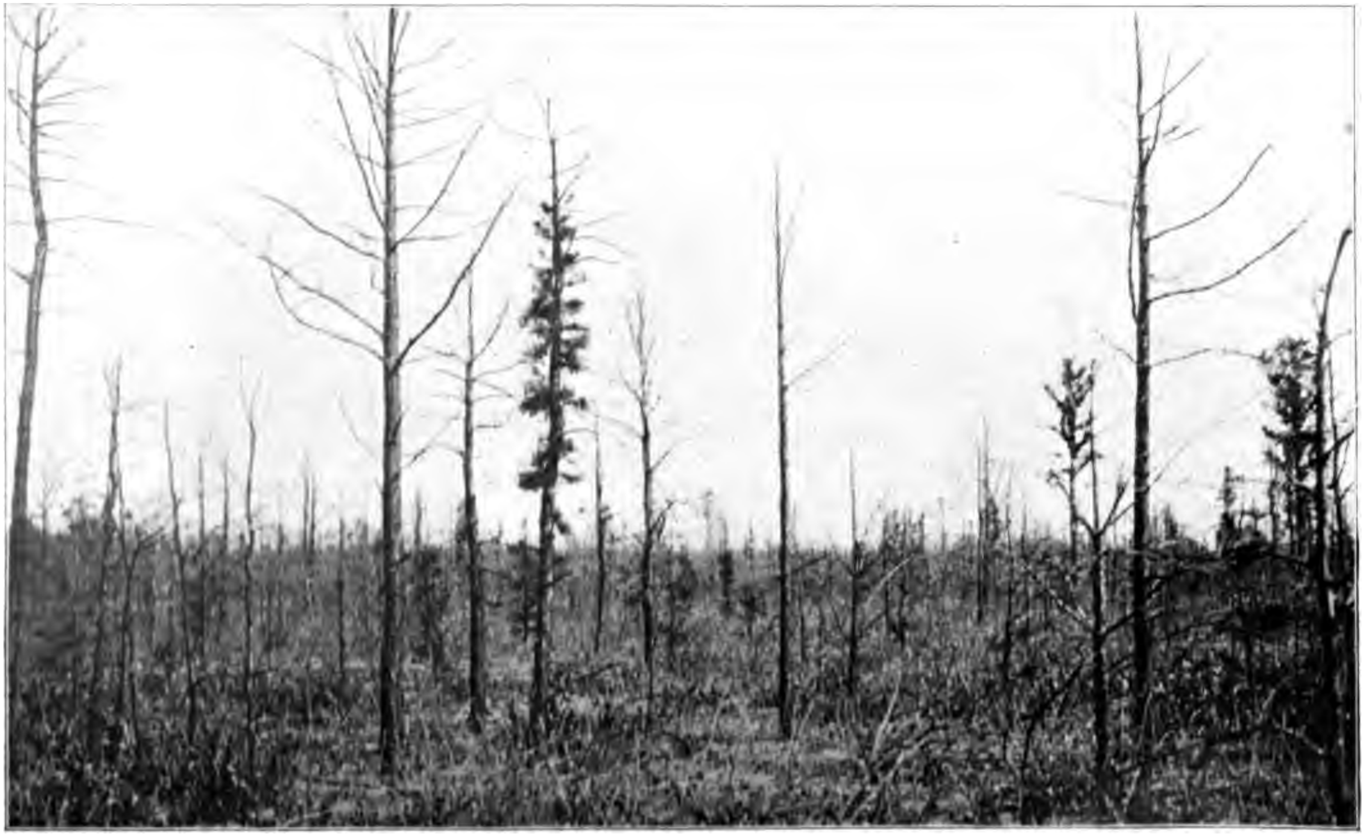


Plate No. VIII.—Repeatedly Burned Land, with Sprouts of Oak and Pine, Tuckerton.

The three sample acres in the next table show the condition of a younger forest, but one which has been more severely burned and is in a lower stage of decline than the preceding acres. The soil is dry and the humus has been almost entirely destroyed. The trees are all crooked and scrubby sprouts of Pitch Pine. There are large numbers of Scrub Oaks on the ground.

Table 15.

Three Sample Acres Showing a Very Advanced Stage in the Deterioration of the Forest Through Fire.

Plot No.	Pine over 2″ in diameter.	Average diameter breast high. Inches.	Maximum diameter breast high. Inches.	Oak over 2″ in diameter.	Average diameter breast high. Inches.	Pine under 2″ in diameter.	Oak under 2″ in diameter.	Density.	Locality.
38	221	3.1	5	. .	. .	466	312	0.4	Near East Plains.
41	177	3.4	6	. .	. .	386	250	0.1	
46	135	3.2	5	83	2.1	62	147	0.3	Spring Hill

By such steps as these the forest has been reduced from a fine old growth of merchantable timber to a straggling, scrubby growth of sprouts. The stage in deterioration next to the last is shown by four surveys taken on land near Tuckerton, which was burned in 1894, and the trees of which had apparently been killed, but had begun to sprout again from the crown and the base. The dead trees, those sprouting at the base and those sprouting in the crown, were all counted separately. It is worth while to note that the larger trees are those which sprout in the crown and that the small trees sprout at the base.

Table 16.

Four Acres Measured Near Tuckerton, N. J., Burned Over in 1894.

Plot No.	Pine sprouting in crown.	Average diameter breast high. Inches.	Pine sprouting at stump.	Average diameter breast high. Inches.	Dead Pine.	Average diameter breast high. Inches.
40	26	5 5	121	4.8	23	6.4
48	73	4.2	130	1.9	230	2.4
49	14	5.5	. .	. .	Not counted	
56	7	6.0	. .	. .		

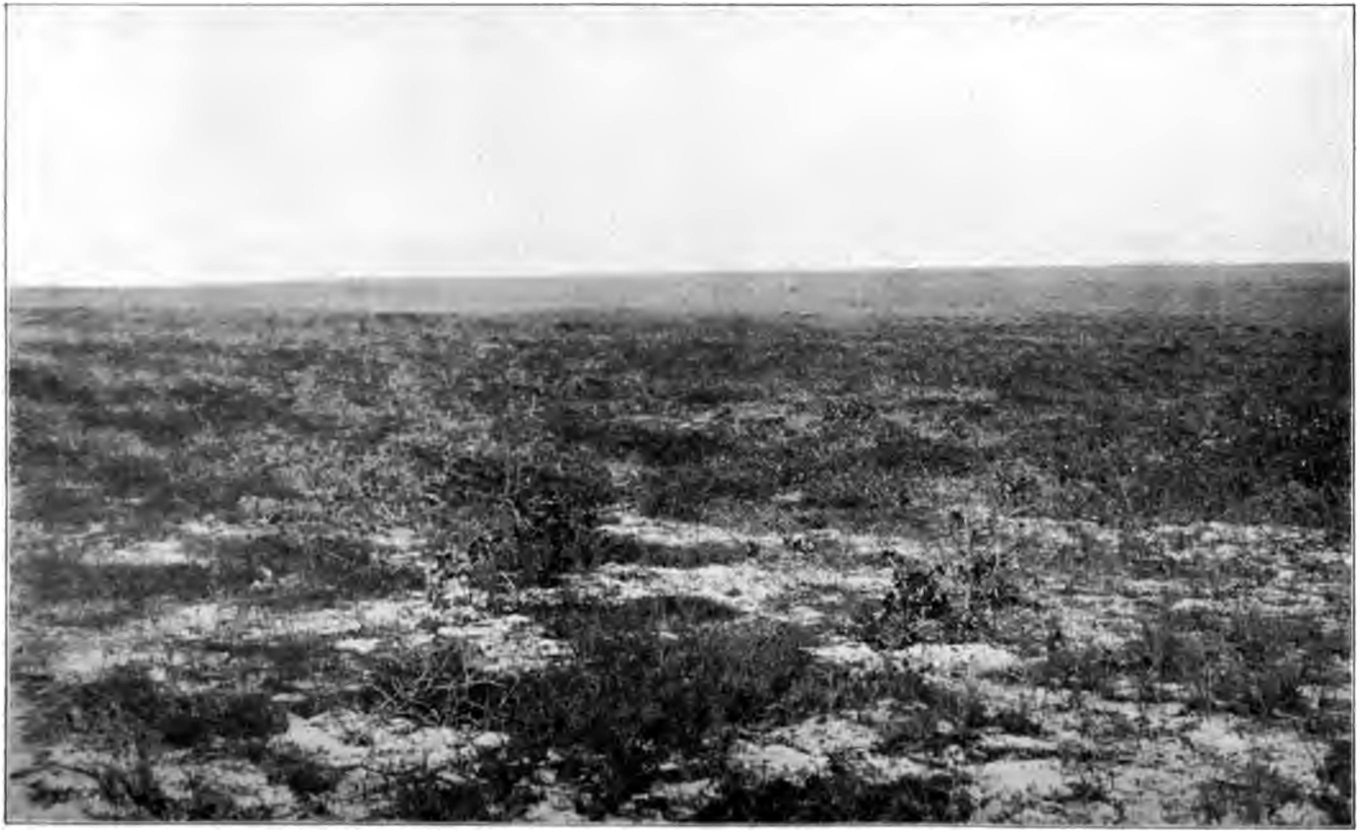


Plate No. IX.—General View of the East Plains.

The Plains.*

The East or Lower Plains are situated for the most part in Burlington county, between Tuckerton and the East Branch of the Wading river. The West or Upper Plains lie nearly north of the East Plains, and are separated from them by this stream. The former cover 7,737 and the latter 6,662 acres.

The land is rolling, with high ridges and deep ravines. On the ridges the soil is a coarse, gravelly sand; in the hollows chiefly sand also, but rather fine in grain. The upper soil is extremely dry, and in places there is a hard subsoil at a depth of one to two feet.

The Plains are for the most part covered with a small and ragged growth of Pitch Pine, Scrub and Black Jack Oaks, Laurel, Bearberry and other small plants of the Heath family. The Pine and Oak are of three descriptions: 1st, a stunted, prostrate growth from two to four feet in height, which covers by far the largest part of the Plains; 2d, Pine from six to fourteen feet in height, very stunted and branching nearly to the ground, with a growth of Scrub Oak below. This growth covers a comparatively small part of the Plains. In many cases fire has killed the trees, and there is but little young sprout growth coming up, but where the land has not been burned so severely young shoots are abundant; 3d, the large Pine, from fourteen to twenty-five feet in height, usually very crooked and scrubby, with a thick growth of Scrub Oak underneath. This growth is rare, and is found only in deep ravines or on the edge of Cedar swamps.

In many cases the Plains are terminated abruptly by large timber. Often, however, the growth merges gradually into that of the surrounding forest. In this case the Pine becomes progressively more erect, the soil takes on a covering of dry-land moss, humus, and shrubs, and the trees finally reach the size characteristic of the surrounding country.

---

* This description is from the Annual Report of the State Geologist for 1898, and is by Gifford Pinchot.

The Pine is chiefly of coppice growth, that is, it consists of sprouts from the stumps or from the creeping branches of trees which have been killed back by fire. If the small specimens are carefully examined, however, it will be found that, although they have the appearance of sprouts, they are in many cases really seedlings, with stems and branches creeping on the ground. Sprouting stumps are found which have been killed back but once, as well as old gnarled burls, veterans of many burnings, covered with knobs from which protrude the charred stubs of dead branches and the new living shoots. Sometimes these burls are compact, almost globular, but more often they take the form of numerous creeping stems, radiating from a common root and sending out sprouts from the knobs of old scars at the end. Dead stumps are common which, in times past, have sprouted again and again, until at length they became exhausted and dead. The age of the main root of a number of such stumps was counted and found to be as much as forty, sixty, and in one case at least one hundred years.

Within the limits of the Plains there are individual specimens of Pine which are erect and growing thriftily. On examination they are found to be healthy seedlings, standing generally in sheltered hollows.

The roots of the Pine on the Plains are often short and poorly developed. This is doubtless due to the lack of moisture and to the hard subsoil, which the roots apparently find difficulty in penetrating.

AGE OF THE PINE.

There is a prevailing opinion that the Pine coppice on the Plains is very old. The Plains are said to have been in their present condition since the country was first settled, and the conclusion is drawn that the trees are nearly two hundred years of age. It may be true that the barren stretches had much the same appearance two centuries ago that they now present, but the sprouts now on the ground are young. Fifty-five stems were cut on the West Plains and their age was counted, and fifty-three on the East Plains. These figures are given in the following tables :

Table 17.

Age of Pine Sprouts on the Lower or East Plains Near Tuckerton, Burlington County, New Jessey.

Height. Feet.	Age. Years.	Height. Feet.	Age. Years.	Height. Feet.	Age. Years.
8	17	5.5	17	4	16
8	15	6	16	5	14
6	11	7	10	3.5	10
8	15	8	14	6	14
8	14	8.5	14	2.5	12
5	12	9	16	4	13
8.5	20	6	14	6.5	18
6	11	8	13	7	19
6	9	3.5	11	2	9

Table 18.

Age of Larger Pine Growing Within the Limits of the Lower Plains.

Height. Feet.	Age. Years.	Height. Feet.	Age. Years.	Height. Feet.	Age. Years.
11	30	11	23	17	38
10	13	13	36	17	41
12	16	13	40	19	43
11.5	15	12	27	21.5	41
12	24	12	28	17	33
20	40	11.5	28	10	22
13	24	21	40	10.5	22
21	46	18	39	13	19
17.5	42			10	22

Table [illegible].

[illegible]

[illegible]

Table [illegible].

[illegible]

[illegible]

[illegible]

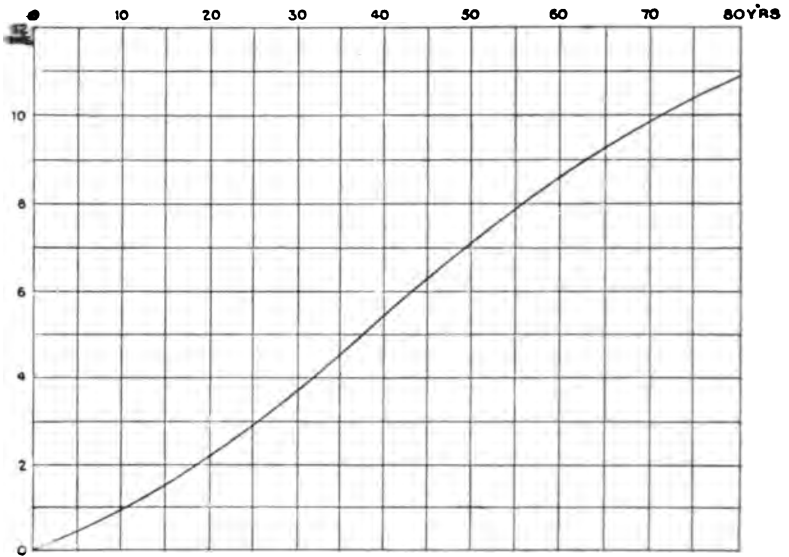
CAUSE OF PRESENT CONDITION.

Many attempts have been made to account for the present condition of the Plains, but these explanations have not been altogether satisfactory. Some have attributed the form of the Pine to a lack of certain mineral constituents in the soil necessary to the growth of trees. This theory, however, is disproved by chemical analyses of the soil made by the Geological Survey, which show no greater poverty than is common to the surrounding region. The theory that fire, combined with the effect of very poor top-soil and a hard subsoil, is the efficient cause, has also been advanced, and certainly fire has been a very large factor in bringing about the present condition of these areas. Sufficient emphasis, however, has not been laid on the fact that the Pine is for the most part of sprout origin, and on the causes of the prostrate form of young seedling trees.

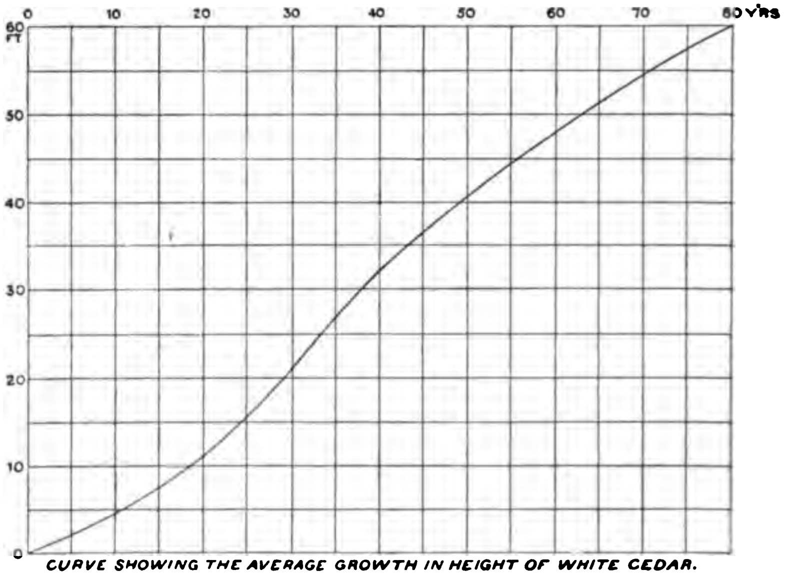
If the Plains have been in their present condition since the country was first settled, they were probably first burned over by the Indians, who were in the habit of camping in the neighborhood, as their shell-heaps show. We know that the western forests are often burned by the Indians to-day, and there is reason to believe that many even-aged stands of Pine in the Eastern States date their origin from fires set by the Indians or by lighting. It is not unreasonable, therefore, to suppose that these high rolling plains were originally stripped of their forest cover in this way. The Pines, which probably returned by seed after the first fire, were burned over again and again, and their stumps sent up sprouts which became more and more feeble after successive fires. Many old stumps, as already pointed out, became exhausted and died after repeated sprouting. Their place was taken by seedlings, and in this way the ground remained stocked with Pine.

This does not explain, however, the prostrate form of the young seedlings and many of the older trees. This peculiarity is not confined to the Plains alone, for Pine seedlings growing on bare sand in exposed situations in the neighborhood of the Plains show the same tendency. These seedlings exhibit a remarkable similarity to the forms assumed by trees near the timber line on high mountains. It is a fair inference that the very harsh and windy situations in which they grow has an effect analogous to that of great elevation. Hence it is believed that exposure and poor soil are entirely sufficient to explain why the young trees are prostrate.

A large part of the Pine, however, is coppice growth from old stumps which have lost their vigor to a large extent, and under the unfavorable surrounding are incapable of producing anything but straggling sprouts. Furthermore, the trees, which grow very slowly on the poor soil of the Plains, are killed by fire before they have time to reach a large size.



CURVE SHOWING THE AVERAGE GROWTH IN DIAMETER OF WHITE CEDAR.



CURVE SHOWING THE AVERAGE GROWTH IN HEIGHT OF WHITE CEDAR.

Plate No. X.—Curves Showing Average Growth of White Cedar.

Silvicultural Notes on the White Cedar.*

FORM AND DEVELOPMENT.

White Cedar grows in very dense stands and has in consequence a short, narrow crown and a long, clear, straight bole. Small pin branches are often scattered over the stem, but they do not seriously affect the quality of the wood. The length of the green crown is as a rule one-fourth to one-third the total length of the tree. The oldest timber studied was about eighty years old, at which age it attains a maximum diameter of fifteen inches and a height of seventy feet. One very old unsound specimen was measured which had a diameter of thirty inches at breast-height and was about seventy feet high. In early youth a tap-root is developed, but in later life the tree has a flat root system, with strong superficial lateral roots.

SITUATION AND SOIL.

The White Cedar is fastidious. It is strictly a swamp tree, and the boundaries of its distribution usually coincide exactly with the edges of swamps, although a few short and scrubby stragglers are found on dry ground. In some cases where a Cedar swamp runs into a Pine swamp the cedar mingles with the Pine and finally runs out where the ground is too dry for it to grow.

Cedar swamps are often classified as wet and dry. In the former there is standing water, a very large amount of sphagnum moss and usually little or no Pine. As a rule the timber is less dense, and it is said to attain smaller dimensions and to be poorer in quality than that growing in dry swamps. In both cases there is a mud bottom, but in dry swamps interlacing Cedar roots cover it with a complete crust. The drier the swamp the greater the proportion of Pitch Pine. A hard-bottom swamp is one in which the trees rest on gravel. It is said that in such situations the trees are apt to be shaky.

---

* By Gifford Pinchot, from the Annual Report of the State Geologist for 1898.

REPRODUCTION.

After the young trees grow large enough for the crowns to meet and form a continuous canopy, no new seedlings spring up. A certain amount of light is required for the germination of the seed. The trees are, however, able to bear very considerable shade, both from above and from the side. This is shown by the very long life of suppressed trees and by the extremely crowded character of the woods. When a Cedar forest is cut, young seedlings spring up in great abundance within two or three years. This is, as a rule, a more complete reproduction in dry than wet swamps, chiefly on account of the amount of standing water in the latter. It has been observed that on badly-burned areas, as a rule, no seedlings spring up for a long time, even though there are seed trees close at hand. From this we must conclude either that the seed from which the usual reproduction springs lies dormant in the soil, waiting to germinate as soon as there is sufficient light, or that the burning of the sphagnum makes an inhospitable bed for the germination of the seed. To show how many young plants come up on a well-seeded area, two small plots were marked off, one of twelve square feet, where the ground was completely seeded, and the other of one hundred square feet, where there were five old stumps and the reproduction was not so thick. On the first plot were found 968 plants, which would make 3,513,840 young trees per acre. On the other plot there were 3,200 plants, equivalent to 1,393,920 per acre.

The youngest tree found to be bearing seed was thirteen years old.

GROWTH.

In view of the value of Cedar, it is important to have some definite figures concerning its rate of growth and its reproductive capacity. On account of the regular growth of the trees and the comparatively even stands, a few measurements will suffice to afford a basis for broad generalization. During lumbering operations at Job's swamp, near Whitings, and at Marigold swamp, near New Gretna, eighteen trees were carefully analyzed. These measurements are summarized below.

Table 21.

Summary of Nineteen Stem Analyses of White Cedar, taken at Job's Swamp, Burlington County, and Marigold Swamp, Ocean County.

Tree No.	Diameter breast high. Inches.	Height of stump. Feet.	Age. Years.	Height. Feet.	Total volume. Cubic feet.	Merch. volume. Cubic feet.	Merch. volume Board feet.	No. of rails.	Current annual growth. Per cent. of whole volume.	LOCALITY.
13	2.3	0.5	39	24.6	0.41	. . .	. .	. .		Job's Swamp.
12	3.9	1.0	49	40.1	1.88	. . .	. .	. .	. .	Job's Swamp.
9	5.8	1.0	79	58.7	5.6	5.2	13	2	. .	Job's Swamp.
17	6.1	0.7	66	56.7	6.0	5.2	13	2	. .	Marigold Swamp.
16	6.6	0.6	65	57.2	7.8	6.5	23	1	. .	Marigold Swamp.
8	6.6	0.7	79	58.0	7.1	6.7	18	2	1.3	Job's Swamp
15	7.1	0.8	66	55.6	8.1	7.0	23	1	1.5	Marigold Swamp.
3	7.4	0.8	77	58.2	8.7	8.3	23	2	1.8	Job's Swamp
14	8.1	0.7	66	58.3	12.5	11.7	32	2	2.8	Marigold Swamp.
4	8.3	0.9	75	61.0	11.0	10.2	28	2	2.2	Job's Swamp.
5	8.6	1.1	77	62.5	12.6	11.8	41	1	2.0	Job's Swamp
18	8.7	0.8	66	64.2	13.8	13.1	37	2		Marigold Swamp.
1	9.0	0.7	77	60.1	12.7	12.0	44	1	2.0	Job's Swamp
2	9.1	0.6	75	57.7	14.1	13.5	50	1	3.0	Job's Swamp.
11	9.4	0.7	80	59.8	12.9	12.3	41	0	2.8	Job's Swamp.
10	10.5	1.2	79	61.6	19.0	17.6	71	0	1.6	Job's Swamp.
7	10.8	1.0	79	58.8	18.6	17.6	62	1	2.2	Job's Swamp.
6	11.2	1.1	79	63.9	21.6	20.3	67	1	1.7	Job's Swamp.

The rate of growth in diameter and height was obtained in the same way as that of the Pine, by plotting the progress of the growth of each tree on cross-section paper and drawing a normal curve through the various points. The values from these average curves are as follows:

Table 22.

Average Rate of Growth in Diameter and Heighth of Seventeen White Cedars.

Age. Years.	Diameter. Inches.	Height. Feet.
20	2.2	11
30	3.7	21
40	5.4	32
50	7.1	40.5
60	8.6	48
70	9.8	54.5
80	10.9	60

The Cedar appears, from this table, to require on an average sixty years to reach a height of fifty feet and eighty years to reach sixty. It is interesting to note that when the forest is thinned the trees grow more rapidly in diameter than when they remain in crowded stands. At Marigold swamp seven stumps were measured of trees which had stood for some years on the edge of a clearing. These trees were growing at the rate of 2.2 inches in diameter in ten years, whereas four trees measured within the same stand showed an average rate of growth of about 1.05 inches in ten years, or a little less than half.

YIELD.

There are few trees, if any, which grow in as dense masses as White Cedar. In order to show the number of trees per acre and the amount of wood at different ages, eight sample plots were measured and the trees counted. These valuation surveys are summarized below. At twenty years of age there were over 10,000 trees per acre, at forty years about 3,500, and at eighty years in one case still over 1,000. Special attention is directed to Plots Nos. 51 and 52. These plots were within a few hundred yards of each other and of about the same age and height. In the first case, however, there are nearly two hundred trees less and a correspondingly larger diameter. While the number of cubic feet per acre is nearly the same the number of board feet is very much larger in the first plot, although there is a smaller number of trees. Plot No. 54 is of about the same age as Plot No. 52, but has only one-half as many trees. These two plots were also very near together, the former on the edge of a swamp. A number of stumps of nearly as large diameter as the trees within the stand were counted and the age found to be the same as in Plot No. 52. In Plot No. 54 there were over 1,000 more cubic feet and over 10,000 more board feet per acre, though the number of trees was only about one-half as great. From these figures it follows: First, that it requires about sixty years to produce lumber in paying quantities; second, that it would pay to thin the forest when it is about forty to sixty years old.

Table 23.

Summary of Sample Areas Surveyed in Job's Swamp, near Whitings, and Marigold Swamp, near Tuckerton, New Jersey.

Plot Number.	Area.	Number of Cedar two inches and over.	Number of Cedar under two inches.	Average diameter breast high.	Maximum diameter breast high.	Average height.	Average age—years.	PER ACRE.				
								Number of trees two inches and over.	Number of trees under two inches.	Board feet.	Cubic feet.	Rails.
	Sq. ft.			In.	In	Ft						
57	400	107	.	0.3	3	20	21	11,663	·	. . .		. .
58	2,500	199	116	2.3	7	35	39	3.463	2,018	. . .	1,420	3,689
	Acres.											
55	0.25	472	2	4.6	8	42	49	1,188	8		5,286	2,676
53	0 25	326	5	5.4	11	48.5	62	1,304	20	9,756	5.868	2,420
51	0.25	214	0	7.2	13	60	66	856		18,244	7.448	1,416
50	0.25	253	0	6.6	13	60	66	1,012	. . .	14,636	7,698	1,568
54	0.25	140	0	9 2	15	65	80	560	. .	25,668	8,910	692
52	0.25	263	0	6.9	12	60	76	1,052		15,596	7,624	1,472

Forests and Water-Supply.

Owing to the importance of the water-supply question in the State, we have given long and careful study to the effect of forests upon the run-off of the streams. As a result, we have reached the following conclusions, resting upon reasons and data which we give later on:

1. Forests have no important effect upon the total evaporation from the stream catchment, consequently the total run-off from forested catchments is not greater than from deforested or cultivated catchments.
2. The springs are better sustained in forested country, the rain-fall being absorbed more readily by the humus and soil of the forest, and the flow of water over the surface to the stream channels being obstructed by roots and other inequalities, consequently forest streams have a more equable flow and are not subject to such long periods of extreme low water.
3. Floods are less frequent on forested streams, owing partly to the above causes and also to the slow melting of snow and ice accumulating in the winter season, but forested streams are nevertheless subject to occasional high freshets.
4. Forest streams carry less mud and silt in suspension. The most desirable conditions for water-supply are found when about three-fourths of the catchments, including the slopes and higher ground, is covered with forests, while the remainder, near the stream lines, is in grass.

In those respects in which the above findings differ from popular opinion they have been verified with great care. Such opinion is largely to the effect that forests decrease evaporation, and that consequently deforestation is responsible for the drying-up of streams. That popular impressions are not always a safe guide is evidenced by the fact that it is commonly alleged in this State that the streams are falling off because of the cutting-off of forests; but the facts, ascertained with much care, are that the area of forests in all of northern New Jersey is as great as it was fifty years ago, and the quality of the timber has been steadily improving for at least forty years. It is therefore clear that if the streams are falling off it is not due to deforestation. There is no competent evidence, based on careful measurement, that there has been any important change in the streams, excepting what may be accounted for by artificial diversions of their waters, or by the fact shown by the rain-fall records that protracted droughts have been more frequent during the last quarter-century than they were during the previous quarter.

While popular opinion is clearly wrong in this case, therefore we believe it is true that by reason of deforestation streams become more fluctuating and subject to longer periods of extreme low water. This would be quite sufficient to account for a popular impression that there is a shrinkage in the run-off. It is quite impossible to determine, except by exact measurements, any change in the total run-off of the streams during the year. More protracted periods of low water would be sufficient to account for many of the phenomena, such as the shrinkage in water-power, etc., which are so often adduced as proof that deforestation increases evaporation. The large volume of water which may have been discharged in floods during the wet season has been lost sight of, as it is of little use for power, and its volume cannot be estimated by the eye.

The conclusions which we have reached are generally similar to those which have been set forth by Antoine C. Becquerel, a member of the French Academy of Science, who devoted most of a long life-time to the subject, and who had at his disposal the best European data.*

He points out the injurious effect upon springs and water-courses due to deforestation, but says: "It cannot be said that this diminution is caused by a less annual rain-fall or a greater evaporation of rain-water."

In his opinion, the real effect is due to a more irregular and flashy discharge of the stream waters. His conclusions are altogether so conservative and embody the results of so much experience and study of European conditions, that his paper is especially commended to the reader's attention.

---

* Memoirs upon Forests and their Climatic Influence; Atlas Meteorologique de L' Observatoire Imperial, 1867 A full translation appears in Report upon Forestry, by F. B. Hough, United States Department of Agriculture, 1877.

EFFECT OF FORESTS UPON EVAPORATION.

A study of this question is of the first importance to the water-works engineer, for it is clear that if evaporation from forested is so much less than from deforested catchments, the amount of run-off which may be collected and utilized for public water-supply will be correspondingly increased. We usually estimate that about 14 inches of rain-fall can be collected yearly in this vicinity, and if forests cause an increase of from 5 to 6 inches in this amount, as has been claimed, the difference in the amount collectible will be very large. It is because we believe that this is an error dangerous to water-supply calculations that we have given special study to this phase of the subject.

The data which throw light upon this subject vary with [illegible] character. First, we have the general facts as to distribution [illegible] forests and rain-fall. In the United States it is found that [illegible] are almost invariably abundant where the rain-fall [illegible] inches per annum, unless there is some peculiar [illegible] unfavorable to tree growth. When the annual rain-[illegible] less than 26 inches, forests almost disappear, but [illegible] raised without irrigation where the annual rain-[illegible] inches. We may infer from this that forests [illegible] support a more abundant supply of water th[illegible] have a verification of these facts in New [illegible] 1881 and 1894 we had protracted droughts [illegible] spring and summer rain-fall fell to [illegible] inches per annum. The actual figures [illegible] Jersey in the spring and summer [illegible] 1894, 15.67 inches, whereas the [illegible] Kansas, at points which have [illegible] amounts to 20.2. During [illegible] numbers of forest trees [illegible] foliage browned as if by fire [illegible] slightly less degree [illegible] [illegible]clude that if the rain-fall [illegible] [illegible]nches per annum [illegible] conclusions [illegible] more the [illegible]

From a statement made in the Strasburger botany, as to the quantity of water required by an oak tree, we must draw the conclusion that a forest of such trees requires from 16 to 19 inches of water during the growing season. The researches of Burger indicate that a mixed deciduous forest, which will cut 40 cords of wood per acre, will require 19 inches of water during the growing season, agreeing well with the above. Von Pettenkofer has stated that during the growing season an oak tree may require eight times the amount of rain falling upon it, and that its roots will draw the required surplus from a great depth.

As to farm crops we have perhaps no more reliable data than the interesting experiments made by Professor King, at the University of Wisconsin.* Based upon these experiments we find that a crop of two tons of clover to the acre requires but 10 inches of rain-fall. This is heavier than the normal field crop. Taking the normal field crop, his results indicate that during the growing season Indian corn requires 4.8 inches, barley 3.6 inches, oats 3.6 inches, wheat 4.5 inches, and potatoes about 10 inches. The average for these crops is 6 inches as against the 16 to 19 inches above estimated to be necessary for forests. We may state here that it is probably true that a very light crop requires much more water per ton of dry matter produced than a very heavy crop, for the reason that with the light crop there will be a larger amount of water evaporated directly from the soil than is the case with a heavy one which keeps the ground well shaded.

Now as to fallow ground we have the careful experiments of Lawes & Gilbert, at Rothamsted, England, which were conducted during a period of twenty years. These show an annual evaporation from soil kept hoed but uncropped amounting to 16.68 inches, with 30.29 inches rain-fall. From April to September the evaporation was 11.46 inches, which may be compared with the above estimates of the requirements for forests, while the evaporation from fallow earth during the growing period for field crops was no less than the amount shown by Prof. King to be the requirement of farm crops.

Taking the annual evaporation from fallow soil, as above determined by Lawes and Gilbert, and comparing it with the evaporation on the Lee and Thames rivers, and Wendover springs, which data we give later in the table of stream measurements, it is found that these three streams give an average evaporation of 20.7 inches annually from catchments covered with the prevailing vegetation of Hertford and Middlesex, against 16.68 from ground without vegetation. We seem to have here quite reliably indicated an excess of 4 inches in annual evaporation caused by vegetation. Lawes and Gilbert themselves are of the opinion that from 3 to 4 inches represents a fair allowance for the excess of evaporation caused by the ordinary vegetation around London over evaporation from fallow soil kept hoed.

---

*"Irrigation and Drainage," by F. H. King.

The experiments of Charles Greaves at Lee Bridge, and of Evans and Dickinson at Nash Mills, appear to show an evaporation from fallow soil almost exactly equal to that shown by the catchments of the above rivers, and on the basis of these experiments there would be no increase of evaporation due to vegetation, but we believe that the above estimate of 3 to 4 inches, based on the experiments of Lawes and Gilbert, is fairly accurate. In our Report on Water-Supply, of 1894, we estimated from the data furnished by the gaugings of the Passaic that evaporation on that water-shed was not increased by the existing vegetation to a greater amount than 6 inches per annum.* This vegetation is made up of 58 per cent. forests; about 6 per cent. wet meadow, which is in grass; 6 per cent. fallow land; 15 per cent. short grass, or pasturage, and 15 per cent. under cultivation. After a recent revision of these estimates our opinion is that the effect of vegetation, such as the above, is to increase the evaporation over what would take place from the same area with no vegetation whatever to the extent of not more than 5 inches per annum. Our own figures are therefore in fair accord with the results of Lawes and Gilbert, and both are based on data derived from conditions closely approximating to those which we find in nature, and confirmed by other estimates which it is impossible to set forth in this paper. We feel justified, therefore, in concluding that the effect of vegetation of any and all kinds upon evaporation has in many cases been much over-rated, and that such vegetation as occurs in the country surrounding London or upon our own Passaic watershed does not increase the annual evaporation over what would take place from fallow, tilled ground more than from 4 to 5 inches. The experiments of Lawes and Gilbert were upon soil kept hoed. Prof. King, in the Wisconsin experiments, shows the effect of cultivation in reducing evaporation. Keeping this fact and the experiments of Greaves, and Evans and Dickinson in mind, it seems probable that evaporation from barren soil, not cultivated, is as great as from soil with vegetation.*

---

* Report on Water-Supply, page 332.

The above cited estimate of 16 to 19 inches, representing the requirements of forest growth, rests upon good authority, but we must not conclude that this means 16 to 19 inches more evaporation from a forested than from a fallow area. Neither must it be concluded that the estimates are reliable for all climates, for we shall show in our discussion of stream measurements that the evaporation from a forested area varies from 20 to 31 inches per annum in the eastern United States, the actual amount being determined by the climate. The same is true of the experiments of Professor King. While they were carefully conducted, and no doubt fairly accurate for the climate of the place of observation, it may be doubted if they will hold good for places having a different climate.

Now, if we adopt the conclusion, that the total effect of vegetation, such as that of the Passaic catchment, is to increase the annual evaportion less than five inches over what would take place from the ground, without vegetation, it is plain that a variation in the amount of forest represented in this vegetation cannot possibly produce an effect upon evaporation so great as five inches.

We will not add to the above, as we have quoted what we regard as the highest authorities, or more satisfactory data, in each case. A large number of early observations of evaporation made in Europe were entirely unreliable, as may be illustrated by the fact that it was for a long time believed in France that the total evaporation from the land surface exceeded the amount of rain-fall thereon. Experiments made on a small scale may diverge widely from conditions which obtain in nature and are never safe guides until abundantly verified.

---

* The controlling cause of evaporation being the capacity of the air to absorb moisture, it will be seen that the water transpired by vegetation goes to supply this demand, consequently it is a part of the water which, in the absence of vegetation, would be drawn direct from the earth into the atmosphere.

A word may be said as to another class of data which have been much quoted as proving increased evaporation due to deforestation. I refer to records of river heights, such as those of Von Wex on the Rhine or Berghaus on the Elbe. According to Von Wex the average height of the Rhine at Emmerich from 1770 to 1780 was 11 Prussian feet 4.1 inches, while from 1825 to 1835 it was only 6 feet 9.2 inches. It will be seen that this is a very great change to take place in fifty years from deforestation alone, so great as to put us on our guard against accepting it as conclusive, for, if long continued, it must result in the entire disappearance of the Rhine. These figures and Von Wex conclusions have been questioned by European authorities. We wish to call attention to the fact that such a change in the average height of rivers is very often the result of a change in the conformation of the river-bed, which may take place at a considerable distance below the point of observation. It may also be due to erosion of the river-bed at the point of observation, but the fact has not been pointed out, to our knowledge, that precisely this effect would result in a change of the stream from steady to flashy conditions, such as we have indicated to be the real effect of deforestation. Thus in our own experience, in two different months a certain stream discharged the same total quantity of water per month, but during the first month it reached a depth of 16 feet only one day, and stood at four feet during the remaining thirty days, showing steady conditions; while during the other month it reached 16 feet on three days and stood at 4 feet on ten days, and about 18 inches on eighteen days, showing a flashy condition. The average depth during the period of steady flow was 4.4 feet, while during the flashy month it was only 3.7 feet, although, as we have said, the total discharge during each of the two periods was the same. This illustrates the necessity of extreme caution in accepting measurements of river height alone as proving a change in the volume discharged by the rivers. Nothing can be accepted as conclusive but actual measurements of the total volume of discharge, which must be accompanied by measurements of the rain-fall.

If we have accurate measurements of the run-off of a stream during a period of years, and contemporaneous measurements of the run-off upon the catchment, the difference between these two may usually be depended upon to represent the total evaporation, including the demands of vegetation. The mean temperature of the atmosphere should be recorded at the same time. Such observations have a scientific value far above the mere determination of the run-off for industrial purposes. The relation between rain-fall, run-off and evaporation is one which needs to be established because of its bearing upon agriculture, drainage, forestry, hygiene and other fields of science and economics. The engineer who gauges a stream should always endeavor to have contemporaneous measurements of rain-fall and temperature.

If we have such measurements as above indicated for a deforested catchment, and also for a forested catchment under similar climatic conditions, it should be possible to determine whether forests have any very appreciable effect upon evaporation. It may be insisted that it is difficult and almost impossible to make such measurements with accuracy, but it should be possible to make gauging with an error not exceeding five per cent., and if the rain-fall can be observed at a number of stations upon the catchment, this also may be closely approximated to, and certainly the result should be sufficiently accurate to show any effect which has economic importance. We have collected, in the following table, the results of such measurements for thirty-four catchments, largely in the eastern United States, with some in the west and a few in England. We have also given the authority for these figures and data, which will enable the reader to understand the care with which the compilation has been made. We do not claim accuracy for these data, but we will show, as we proceed with the analysis, that there is sufficient consistency in the results to warrant such conclusions as we have attempted to draw from them.

Results of Stream Gaugings.

RIVER.	Length of Record. Years.	Area of Catchment. Square Miles.	Annual Rainfall. Inches.	Annual Run-Off. Inches.	Annual Evaporation. Inches.	Per cent. of Forest Area.	MEAN TEMPERATURE. Year. Degrees.	Summer. Degrees.
New England—								
Merrimac, ...	7	4,533	39 73	20.30	19.43	40	44.6	64.6
Sudbury, ...	24	75	46.19	22.57	23.62	14	48.	68
Cochituate, ...	24	19	44.19	19.89	24.30	Small.	48.	68.
Mystic, ...	24	27	43.73	20.11	23.62	Small.	48.	68.
Connecticut, . . .	15	10,234	44.48	23.61	20.87	53	44.5	65.8
New York—								
Croton (1), ...	25	353	48.38	23.51	24.87	30	48.	68.
Croton (2), ...	14	353	44.73	22.13	22.60	30	48.	68.
Upper Hudson, . .	6	4,500	43.73	22.54	21.19	80	41.8	64.
Genessee, ...	3	1,070	40.16	12.95	27.21	27	45.1	66.3
Hemlock Lake, . .	5	43	27.82	13.12	14.70	Large.	45.	66.3
Skaneateles Lake, .	4	60	36.20	17.34	18.86	12	45.	65.4
New Jersey—								
Hackensack, . . .	9	115	47.55	22.94	24.61	60	48.5	69.
Passaic	17	822	47.09	23.71	23.38	58	48.	68.5
Pequannock, . . .	8	65	50.90	26.85	24.05	78	46.	66.
Ramapo, ...	2½	160	48.19	24.31	23.88	75	47.	67.
Musconetcong, . .	2	156	44.52	23.55	20.97	39	47.5	69.
Pequest, . . .	2	158	43.87	23.33	20.54	18	48.5	68.5
Paulins Kill, . . .	2	175	46.48	24.28	22.20	27	49.	69.
Raritan, ...	4	789	45.50	21.75	23.75	13	50.	70.
Batsto, ...	2	70	48.39	20.48	27.91	88	51.5	71.5
Great Egg Harbor,	3	216	52.03	23.10	28.93	88	51.5	72.
Pennsylvania—								
Tohickon, ...	12	102	50.25	28.93	21.32	24	51.	71.
Neshaminy, ...	12	139	47.69	23.33	24 36	6	52.	72.
Perkiomen, ...	12	152	48.07	23.85	24 22	25	52.	72.
Other States—								
Potomac, Va , . .	6	11,043	43.51	18.69	24.82	52	54.	75.
Savannah, Ga., . .	8	7,294	54.04	22.19	31.85	65	61.	77.
Muskingum, O., .	8	. . .	39.99	12.65	27.32	Small.	52.	73.
Desplaines, Ill., . .	8	. . .	32.37	7.37	25.00	Small.	47.	70.
Kansas, Kan., . .	10	59,841	25.10	0.97	24 10	Very Small.	52.	73
Clear Creek, Col., .	20	436	20.62	7.77	12.85	Wooded.	40.	. .
Sweetwater, Cal., .	7	186	24.86	2.97	21.89	. . .	54.	. .
England—								
River Lea, ...	3	444	28.75	6.9	21.8	Small.	51.	. .
Wandle, ...	3	64	38.8	9.5	29.3	Small.	51.	. .
Thames, ...	.	1,200	27.63	7.33	20.3	Small.	51.	. .
Wendover Springs,	41		29.04	9.00	20.0	Small	51.	

Appended is a list of the authorities from which the above data are drawn:

AUTHORITIES AND REMARKS.

Merrimac.—Reports of Massachusetts Board of Health, 1892 to 1898, inclusive, give the run-off. Rain-fall and temperature are compiled from records of U. S. Weather Service and New England Weather Service.

Sudbury, Cochituate and Mystic. - From Nineteenth Annual Report of the Boston Water Board. The Cochituate record begins in 1863, but the early years seem less reliable, so that I have used the record from 1875, making it cotemporaneous with the Sudbury.

Connecticut.—From Results of Stream Measurements, U. S. Geological Survey, 1895. The year 1871 is incomplete while 1873, 1874 and 1876 show run off from December to May so largely in excess of rain-fall that I have rejected them in making up the averages. Temperature from U. S. Weather Records. The original stream gaugings were made by the U. S. Engineer at Hartford

Croton (1).—Originally compiled for the Report on Water-Supply, published by the Geological Survey of New Jersey in 1894. Run-off from Reports of Department of Public Works, of New York City. Corrected for amounts drawn from or supplied to storage. Area of catchment 353 square miles, from survey made by the author, for New Croton Aqueduct Commission, which survey is based on accurate triangulation, and area is computed geodetically. The area long in use by Department of Public Works is 338 square miles based on a traverse survey, necessarily less accurate. The use of the correct area is important in this connection, as it makes the depth of run-off 4.4 per cent. less than that given in the department estimates.

Croton (2).—These figures are taken from the Report of the Croton Aqueduct Commission, 1887-1895. The depth of the run-off is corrected to conform to the correct area, 353 square miles, as above described.

Upper Hudson.—From MS. furnished by Geo. W Rafter, C. E.

Genessee.—From MS. furnished by Geo. W. Rafter C. E. These and the Upper Hudson records are the ones referred to by him in a paper on "Stream-flow in Relation to Forests." Proceedings American Forestry Association, Vol. XII.

Hemlock Lake.—Measurements made by the Rochester Water Department and furnished by J. Nelson Tubbs C. E.

Skaneateles Lake.—Run-off from records of the Syracuse Water Department. Rain-fall and temperature from records of New York State Weather Service.

Hackensack.—Run-off from records of Hackensack Water Co. Reorganized. Chas. B. Brush, engineer.

Passaic.—Run-off from records originally used for Report on Water-Supply, Geological Survey of New Jersey, 1894, which have been re-computed and checked.

Pequannock.—Run-off furnished by Clemens Herschel, C. E., Supt. East Jersey Water Company. Rain-fall prepared from N. J. State Weather Service records for Charlottesburg, etc., as the Oak Ridge record furnished by Herschel does not appear to be representative of the rain-fall on the water-shed.

Other New Jersey Streams.—From Report on Water-Supply, Geological Survey of New Jersey, 1894. Temperature revised to date from records of New Jersey State Weather Service.

Tohickon, Neshaminy, Perkiomen.—Annual Reports of Philadelphia Water Department, also paper in Vol. XIV, Proceedings of Engineers' Club of Philadelphia, by John E. Codman.

Potomac.—The Hydrography of the Potomac Basin, by Cyrus C. Babb, Proc. Am Soc. C. E., Vol. XXVI. Two years of this record show such large discrepancies in run-off as compared with the rain-fall that they are rejected in making up the average.

Savannah.—Results of Stream Measurements, U. S. Geological Survey, 1891, page 148. Instead of taking the rain-fall of Augusta alone I add 19%, which is the average excess over Augusta rain-fall shown by five stations which fairly represent the entire water-shed.

Muskingum, Desplaines.—"Stream-flow in Relation to Forests" Geo. W. Rafter. Proceedings American Forestry Association, Vol. XII.

Kansas.—Bulletin 140, U. S. Geological Survey, and rain-fall from U. S. Weather Service Bulletins.

Clear Creek.—Vol. XVII, Tenth Census, p. 52 (336).

Sweetwater.—Bulletin 140, U. S. Geological Survey, p. 322.

Lea—Transactions American Society of Civil Engineers, Vol. XVIII, p. 297.

Wandle, Thames, Wendover Springs.—Proceedings Institute of Civil Engineers, Vol. CV, p. 56, etc.

A careful examination of the foregoing table must convince any candid observer that there are more potent agencies than forests effecting the evaporation; thus the evaporation on several streams, which have more than half the area of catchment covered with forests, is as follows: Connecticut, 20.87; Upper Hudson, 21.19; Hackensack, 24.61; Passaic, 23.38; Great Egg Harbor, 28.93; Potomac, 24.82; Savannah, 31.85.

Here we have a range of 11 inches in evaporation without a corresponding range in forest conditions, and it will be found that generally the larger evaporation corresponds with the higher temperature. While, in the State of New York, the short three-year series on the Genessee river appears to show about 6 inches more evaporation than the figures for the Upper Hudson; on the other hand, the deforested catchment of Skaneateles lake shows 2.3 inches less than the forested Hudson; and the Connecticut, with fifty-three per cent. of forests, shows larger evaporation than the Merrimac, with but forty per cent.; while the highest evaporation in the table is shown by the well forested Batsto, Great Egg Harbor and Savannah catchments.

Indeed, the variation in evaporation can only be satisfactorily accounted for by the differences of rain-fall and temperature. We have been able to determine accurately the effect of varying rain-fall from the fact that this can be studied in the long records of a single stream, such as the Sudbury, Cochituate, Mystic, Croton or Passaic. Beginning with these streams and working out to the others shown in the table, and also taking into consideration the well-known law by which the capacity of the atmosphere to retain moisture is determined by the temperature, we have evolved the following equation to express the relation between evaporation (E.), rain-fall (R.), and temperature:

$$E = (11 + .29R)\ M.$$

In this equation M is a factor depending upon the mean temperature of the atmosphere.[*]

Now, if we take from the table of stream measurements the given rain-fall and temperature for each catchment, and by means of this formula compute the evaporation, that computation will give us what the evaporation should be if it is influenced only by rain-fall and temperature. If the observed evaporation differs from this computed evaporation, the difference may possibly be accounted for by the influence of forests, humidity, wind, or difference in the distribution of rain-fall through the year. We might expect to find that humidity affects the evaporation to some extent in case this humidity is derived from the sea or other large water-surfaces in the vicinity of the catchment. We are not perpared to say that under these conditions it has not some effect, but the results of our studies given later indicate that this effect is a minor one. It is possible that the evaporation on southern stream basins is somewhat decreased by this influence, while on the Kansas, Desplaines and similar interior streams, it may be relatively increased.

---

[*] Values of M for given temperatures are as follows:
40°—0.77, 41°—0.79, 42°—0.82, 43°—0.85, 44°—0.88, 45°—0.91, 46°—0.94, 47°—0.97, 48°—1.00, 49°—1.03, 50°—1.07, 51°—1.10, 52°—1.14, 53°—1.18, 54°—1.22, 55°—1.26, 56°—1.30, 57°—1.34, 58°—1.39, 59°—1.43, 60°—1.47, 61°—1.51.

Wind increases evaporation, but its influence to cause variation between catchments is limited because the variation in the total amount of wind through the year is limited. If we had a catchment on which the wind blows all the time to compare with one on which there is little or no wind, no doubt the difference in evaporation would be appreciable.

In case the summer rain-fall is large, the evaporation will be greater than that given by the formula, which is based upon such rain-fall as that of the Eastern and Middle States, which is quite evenly distributed through the year. This difference may be taken into account by monthly or seasonal formula, but this is a matter of too much detail for the purposes of this paper.

Such a computation as we have indicated is made in the following table. The streams are grouped into deforested catchments, having less than 40 per cent. of the area in forests and forested catchments having more than this percentage.

Observed Evaporation Compared with Evaporation Computed on the basis of Rain-fall and Temperature.

DEFORESTED CATCHMENTS.

STREAM.	Per cent. of Forest.	Observed Annual Evaporation.	Computed Annual Evaporation.	Difference. Inches.	Difference. Per cent
Sudbury,	14	23.6	24.4	—0.8	—3
Cochituate,	Small.	24.3	23.8	+0.5	+2
Mystic,	Small.	23.6	22.6	0	0
Croton,	30	24.9	25.0	—0.1	0
Genessee,	27	27.2	20.6	+6.6	+24
Skaneateles,	12	18.9	19.6	—0.7	—4
Musconetcong,	39	21.0	23.7	—2.7	—13
Pequest,	18	20.5	24.0	—3.5	—17
Paulinskill,	27	22.2	25.2	—3.0	—14
Raritan,	13	23.7	25.9	—2.2	—8
Tohickon,	24	21.3	28.2	—6.9	—32
Neshaminy,	6	24.4	28.3	—3.9	—16
Perkiomen,	25	24.2	28.2	—4.1	—17
Muskingum,	Small.	27.3	25.7	+1.6	+6
Desplaines,	Small.	25.0	19.8	+5.2	+21
Kansas,	Small.	24.1	20.5	+3.6	+15
Sweetwater,	Small.	21.9	22.2	—0.3	—1
Lea,	Small.	21.8	21.3	+0.5	+2
Wandle,	Small.	29.3	24.5	+4.8	+17
Thames,	Small.	20.3	20.9	—0.6	—3
Wendover Springs,	Small.	20.0	21.4	—1.4	—7

FORESTED CATCHMENTS.

Merrimac,	40	19.4	20.3	—0.9	—5
Connecticut,	53	20.9	21.5	—0.6	—3
Upper Hudson,	80	21.2	19.1	+2.1	+10
Hemlock Lake,	Large.	14.7	17.4	—2.7	—18
Hackensack,	60	24.6	25.2	—0.6	—2
Passaic,	58	23.4	24.7	—0.7	—3
Pequannock,	78	24.1	24.2	—0.1	—0
Ramapo,	75	23.9	24.3	—0.4	—2
Batsto,	88	27.9	28.0	—0.1	—0
Great Egg Harbor,	88	28.9	29.1	—0.2	—1
Potomac,	52	24.8	28.9	—4.1	—17
Savannah,	65	31.8	35.7	—3.9	—13
Clear Creek,		12.9	13.1	—0.2	—2

Excepting for the Savannah, the mean temperature is used in all cases, but for that stream the summer temperature is decidedly lower, as compared with the mean for the year, than for other streams, consequently as the summer is the season of maximum evaporation, the evaporation is estimated on the basis of the summer temperature.

The fifth column of this table gives, in inches, the amount by which the measured evaporation is greater or less than the evaporation computed from rain-fall and temperature, and the last column shows the percentage of the measured evaporation which this discrepancy represents. It is not usually to be expected that the measurements are correct within five per cent., considering possible errors in both rain-fall and stream measurements; therefore, it is significant that 17 streams having an average length of record of 12 years, differ from the results given by the formula less than 5 per cent., the mean being but 1½ per cent., while three more, with average records of 11 years, vary from 6 to 8 per cent., the algebraic mean being 3 per cent., and the remaining 14 streams, which differ more widely, have an average length of record of 6.5 years only, the average difference for these being 5 per cent. As has been previously intimated, these larger differences would, in many cases, be reduced by a more detailed computation, which would take into account the distribution of rain-fall by seasons. The burden of evidence of these stream gaugings, therefore, is heavily against the theory that forests, or any other cause except rain-fall and temperature, affects evaporation to any important extent.

The large excess of evaporation on the Genessee is unaccountable. No such excess appears on the Skaneateles, which has a similar climate, and is even more deforested, but the excess on the Desplaines and Kansas is fully accounted for by the large excess of spring and summer over fall and winter rain-fall.

The excess on the Wandle, in England, is possibly attributable to escape of the water downward into the chalk, but the figures for the Lea, Thames and Wendover Springs agree quite closely with our formula. It is remarkable that the Sudbury, with 14 per cent., the Merrimac, with 40; the Connecticut, with 53; the Skaneateles, with 12; the Raritan, with 13; the Hackensack, with 60; the Passaic, with 58; the Ramapo, with 75, and the Egg Harbor and Batsto, with 88 per cent. of forest area, all conform closely to the formula, showing that a range from 12 to 88 per cent. in forest area is not sufficient to materially affect the evaporation. Allowing for differences due to seasonal distribution of rain-fall, it seems to be sufficiently clear that a formula based only upon rain-fall and temperature can be made to harmonize the results of stream gaugings as closely as the unavoidable errors of gauging and rain-fall measurement will admit of. Indeed, if it seemed warrantable, for the purposes of this paper, to introduce extended computations by months instead of by years, it could be shown that all influences, except temperature and rain-fall, are practically negligible in determining evaporation and stream yield, so far as is shown by the best records of measurement now available. Consequently, we conclude that stream gaugings show no decrease of evaporation owing to the presence of forests upon the catchments.

Another class of experiments often quoted in this connection has no bearing at all upon the relative evaporation from a wooded or an open country, so far as it affects the streams. I refer to those, such as Dr. Ebermayer's, which show that the evaporation from a water-surface, or from the soil beneath the forest trees, or beneath the litter of the forest, is less than in the open. This we readily concede to be true, but we must determine whether or not this is offset by the large volume of water taken up by the roots of the tree and transpired from its leaves into the atmosphere above the tree-tops. Nor, again, can we believe that it would not be found that evaporation from beneath the leaves of a heavy crop of Indian corn or clover would also be less than in the open. The same answer applies to the statement that temperature beneath the forest trees being less, on our theory that evaporation is so much affected by the temperature, this would call for a less evaporation from forests. What it does call for is a less evaporation beneath the leaves of the forest, which we have already stated is undoubtedly the fact, but it cannot affect the evaporation measured, as it must be, above the level of the tree-top. It ought not to be necessary to remind scientific writers that it is not proper to measure evaporation from crop areas so as to include water taken up by the plants, and evaporation from forests so as not to include water taken up by the trees, and then attempt to compare these two measurements in order to determine relative evaporation from forest and from farm crops. (See Proceedings of the American Forestry Association, Vol. XII, page 157.)

EFFECT UPON MAXIMUM AND MINIMUM FLOW OF STREAMS.

While we have pointed out the beneficial effect of forests in equalizing the flow of streams, this effect does not appear in the maximum and minimum flow. The reason is that the severest floods occur under such conditions as that of a warm rain falling suddenly upon a heavy accumulation of snow, or upon ground frozen in such a manner that it cannot be absorbed. Or if it is in summer, the ground may already be so saturated with water as to prevent further absorption. Forests are powerless to prevent floods under such extreme conditions as these, although they do diminish the number of floods.

In the same manner the extreme low point is reached when the streams have been for a long time drawing upon their springs and have extracted the water from the ground to a considerable depth below the surface. Our investigations show that the lowest discharge is usually reached when the water has been drained from the subsoil to an average depth of over four feet. It should be evident that when the water which feeds the stream is coming from points so far beneath the surface, the humus or other surface peculiarities of forests can have little effect upon the rate of its discharge. The following table shows the greatest and least rate of discharge on various streams and the percentage of catchment area covered with forests:

CATCHMENTS LESS THAN 200 SQUARE MILES.

	Catchments in Square Miles.	Per cent. of Area in Forest.	Flood Flow in Cubic Feet per Second per Square Mile.	Lowest Flow in Cubic Feet per Second per Square Mile.
Sudbury, Mass., ...	78	14	41.4	0.036*
Croton, West Branch, N. Y.,	20	56	54.4	0.020
Ramapo, N. J., ...	160	75	66.1	0.140
Wanaque, N. J., ...	101	75	48.9	. . .
Wanaque, N. J..	73	85	99.0	. . .
Pequannock, N. J., . . .	48	78	115.0	. . .
South Branch, N. J., . . .	67	30	113.0	. . .
Rockaway, N. J., ...	119	82	43.0	. . .
Musconetcong, N. J., . .	130	30	45.0	. . .
" " . .	36	85	64.0	
Paulins Kill, N. J., . . .	175	27	26.0	0.130
" " . . .	126	27	54.0	
Swartswood Lake, N. J., .	16	22	65.8	. .
Pequest, N. J., ...	158	18	13.0	. . .
" "	83	18	9.6	0.170
" "	35	18	18.7	. .
" "	2	. .	25.3	. . .
Tohickon, Pa , ...	102	28	55.3	0.001
Neshaminy, Pa., ...	139	7	41.4	0.009
Perkiomen, Pa., ...	152	25	34.9	0.050
Hackensack, N. J., . . .	115	60	. .	0.190

CATCHMENTS OF 200 TO 2,000 SQUARE MILES.

Concord, Mass., ...	361	. .	12.3	0.17
Charles, Mass., ...	215	. .	. .	0.20
Housatonic, Conn., . . .	790			0.17
Croton, N. Y., ...	339	30	74.9	0.15
Passaic, N. J., ...	797	59	24.2	0.19
" "	822	58	22.2	0.19
Raritan, N. J., ...	879	13	68.0	0.14
South Branch, N. J., . . .	276	13	100.0	
Great Egg Harbor, N. J., .	216	88	22.0	0.27
Schuylkill, Pa., ...	1,800		. .	0.17
Potomac, Md., ...	920	52	19.5	0.02
Greenbrier, Va., ...	870	. .	.	0.12
Shenandoah, Va., ...	770		. .	0.17
Neuse, N. C., ...	1,000	. .	. .	0.19

---

* This has since fallen lower because of the construction of artificial reservoirs, causing increased evaporation.

CATCHMENTS OVER 2,000 SQUARE MILES.

Merrimac, Mass., ...	4,599	. .	20.9	0.31
Connecticut. Conn., . . .	10,234	53	20.3	0.31
Delaware. N. J., ...	6,790	53	37.5	0.17
Ohio, Pa., ...	19,900	. .	. .	0.11
Potomac, Va., ...	4,640	52	22.2	0.08
Kanawha, Va., ...	8,900	. .	13.5	0.12
James, Va., ...	6,800	. .		0.19

Since the flood-flow is always at a less rate per square mile on large catchments than on small ones, we have grouped the streams according to the size of the catchment. It will be seen that there is no relation between the forest area and either the greatest or least flow.

In February, 1896, during the progress of these forest surveys, floods of great severity occurred on all of the streams of Northern New Jersey, and a good opportunity was afforded to study the relative rate of discharge on forested and deforested catchments. These floods were caused by a warm rain, amounting to about 3.7 inches, falling upon an accumulation of from 6 to 7 inches of snow, the ground being frozen; and of the total amount of water resulting, equivalent to about 4½ inches of rain, 2.7 to 3.7 inches was discharged with great suddenness into the streams. Careful studies were immediately made of the rate of discharge and the results are shown in the following table:

Maximum Rate of Discharge, February 6, 1896.

CATCHMENTS.	Area in square miles.	Percentage of forest.	Cubic feet per second per square mile.
Raritan, ...	879	13	68
Passaic, ...	822	58	22
Pompton, ...	285	76	65
South Branch, ...	276	13	100
Paulins Kill, ...	175	27	26
Ramapo	160	75	54
Pequest, ...	158	18	13
Musconetcong, ...	130	30	45
Paulins Kill, ...	126	27	54
Rockaway, ...	118	82	43
Ramapo, ...	86	80	56
Wanaque, ...	73	85	99
South Branch, ...	67	30	113
Pequannock, ...	48	78	115
Whippany, ...	38	36	84
Musconetcong, ...	36	85	64
[illegible] Brook, ...	10	5	140

In this table, wherever the flood has been held back by storage reservoirs, the maximum rate of flow is taken to be that of that portion of the catchment not affected by such holding back. Such correction has been made on the Pompton for the storage reservoirs of the East Jersey Water Company and for Greenwood lake, but several other natural lakes upon the catchment have not been allowed for, so that the maximum rate for the Pompton is undoubtedly still reduced by these other lakes. The maximum rate on the Pequannock is taken to pertain only to the portion of the catchment below the East Jersey storage reservoirs. For the Wanaque the catchment has been reduced by throwing out the part controlled by Greenwood lake, although nothing is allowed for Sterling lake. The Musconetcong maximum is also corrected by throwing out the portions of catchment controlled by lake Hopatcong and Stanhope reservoir. The maximum rates of discharge here given are consequently sufficiently accurate to admit of comparison. The table is convenient for ready reference and general comparison, but without allowing for local peculiarities no useful lesson can be learned from it as to the effect of forests upon flood-flow. The maximum rate of discharge measured in this way is effected by purely local conditions, mainly by the shape of the valley at the point where the measurement is taken. The velocity of discharge down the valley is determined by the depth of the water and the slope of the valley above the point of gauging. It is also affected to a less degree by the capacity and slope of all the valleys of the catchment. Where these are flat, so that the water can spread, no great depth can be attained, and the rate of discharge is consequently lower. The retarding effect of forests, if any exist, would be better shown by the rate at which the water comes in to the valleys from the surrounding slopes. Thus, on the Raritan, we determine by taking the accumulation of water between the dam below Bound Brook and the mouth of the Millstone, that for six hours the water was discharged into this portion of the valley at a rate which averaged almost as high as the maximum recorded for a short time at the dam, and from this we must infer that the maximum rate of discharge into the valley above the dam was much higher. On two water-sheds exactly similar in topography, the rate of discharge will be greater as the size of the water-shed is less. This fact appears throughout the table, and allowing for this it is impossible to detect any relationship between the maximum rate of discharge and the percentage of forest on the catchment. The relative height of a flood, as generally understood, and its destructiveness, are accurately measured by the maximum discharge above shown. On two catchments fairly similar in topography, one of which is largely forest-clad and the other deforested, the forest-clad water-shed should show a lower rate of flow if forests exert a controlling effect upon such extreme floods. The Ramapo at Pompton and the Paulinskill at Hainesburg seem to be fairly comparable. The former with 75 per cent. of forest shows a maximum rate of 54, while the latter with 27 per cent. of forest shows a maximum rate of but 26. Again, the upper Ramapo with 80 per cent. of forest shows a maximum rate of 56, while the Wanaque with 85 per cent. of forest shows a rate of 99, and the Pequannock, with 78 per cent. of forest, a rate of 115. The Pequannock shows about the same maximum rate as the South Branch at High Bridge, although the latter has only 30 per cent. of forest. There are enough of such instances to entirely break the force of the cases in the table which seem to show a higher rate for a less percentage of forest, such as the Pompton and the south branch of the Raritan, or the Whippany and Upper Musconetcong, and the conclusion is inevitable that any effect which forest may have upon the maximum rate of discharge is entirely subordinate to other controlling influences which we have stated to be mainly topographic.

The destructive character of the flood under consideration, which in most places seems to have been higher than any previously recorded, has, as usual, been freely attributed to deforestation. We repeat our caution that the mere fact that a flood is higher at a given point than heretofore, does not mean, necessarily, that its rate of discharge was greater, but may mean that the valley has been artificially obstructed during recent years by bridges, dams or embankments. Admitting, however, that this flood generally had a higher rate of discharge, we must bear in mind the absolute dearth of evidence either that the area of forest is less, or that its condition is in any way inferior to that of 1850.

Returning to the analysis of this flood, the following table presents, in a more satisfactory way than the foregoing one, data which may indicate retardation of the discharge by forest, if it exists:

Discharge by Periods, February 6, 1896.

IN INCHES ON CATCHMENT.

CATCHMENT.	Area in square miles.	Per cent. of forest.	Discharge in given hours from beginning. 12*	24	48	72
Passaic at Dundee, ...	822	58	0.10	0.36	1.13	1.72
Raritan at dam, ...	879	13	0.41	1.48	2.43	2.74
Passaic at Two Bridges, . . .	773	58	0.61	1.55	2.37	2.72
Raritan at Bound Brook, . .	879	13	0.63	1.59	2.43	2.74
Pompton, ...	350	76	0.71	1.55	2.42	2.89
Ramapo, ...	160	75	0.54	1.34	2.62	3.13
Paulinskill, ...	126	27	0.39	1.20	2.31	2.91
Rockaway, ...	118	82	0.44	1.21	2.08	2.50
Ramapo, ...	86	80	0.55	1.32	2.54	3.01
South Branch, ...	67	30	1.13	1.73	2.60	3.12
Pequannock, ...	63	78	1.42	2.45	3.22	3.53.
Musconetcong, ...	37	85	1.12	2.27	3.53	3.73
Lake Hopatcong, ...	22	94	. .	2.37	3.01	. .

Percentage of Total Discharge.

BY CONSECUTIVE PERIODS.

	First 12 hours.	Second 12 hours.	First 24 hours.	Second 24 hours.	Third 24 hours.
Passaic, ...	23	34	57	30	13
Raritan, ...	23	35	58	31	11
Pompton, ...	25	29	54	30	16
Ramapo, ...	17	26	43	41	16
Paulinskill, ...	13	28	41	38	21
Rockaway, ...	18	30	48	35	17
Ramapo, ...	18	26	44	40	16
South Branch, ...	36	19	55	28	17
Pequannock, ...	41	29	70	22	8
Musconetcong, ...	30	31	61	34	5

In the first of these tables the figures first given for the Passaic at Dundee and Raritan at the dam are for flow locally restricted. In the case of the Passaic this comes about through the operation of the extensive flats and the restricted outlet at

Little Falls, while in the case of the Raritan it is due to the dam itself and other artificial obstructions. In the figures next given for the Passaic at Two Bridges and Raritan at Bound Brook, this is corrected, the Passaic figures being also corrected to allow for water stored in lakes and reservoirs, and we have the rate at which the water came in immediately above the point of restriction. These two, together with the Pompton, represent catchments large enough to be free from local and accidental features. The discharge by periods does not show any effect traceable to forest conditions, indeed, the rapidity of discharge is somewhat greater on the well-forested Pompton catchment, and the figures are nowhere higher than for the well-forested Pequannock. In general the discharge in inches of depth for the first day will be greater as the catchment decreases. This law is well exhibited in the 24-hour period. Taking the whole 72 hours the volume of flood-discharge is seen to vary materially on different catchments. This may be due to local differences in the amount of rain or snow, or in the absorbent power of the soil. It does not appear to be less on the forested catchments. In order to eliminate the effect of differing volume of total discharge the second table is made up to show what percentage of the total was discharged during the first and second 12-hour periods and during the three 24-hour periods from the beginning. In these tables the agreement between the forested Passaic and deforested Raritan catchments is striking. The Pompton, being a smaller catchment, naturally shows a little higher rate for the first 12 hours. But it is about four per cent. less during the first 24 hours, this four per cent. having been carried over and discharged during the third day. We are of the opinion that this slight retardation is attributable to the lakes and ponds entirely. That it is not due to the high percentage of forest seems proven from the fact that on the Ramapo, one of the branches of the Pompton having about the same percentage of forest, the retardation is considerably greater than on the Pompton. Lakes and ponds operate also in the case of the Rockaway to produce a similar result. The South Branch of the Raritan shows a more rapid discharge than the foregoing streams, but less rapid than the much better forested Pequannock and Musconetcong, showing clearly that the difference is chargeable mainly to the decreasing size of the catchment, and not to deforestation.

There is nothing in the history of floods on the rivers of the State which can be accepted as proof that there has been an increase in the height to which they rise, excepting such increase as may be accounted for by the building of dams, railroad embankments and other artificial obstructions which interfere with the discharge.

On the Delaware we have records of a great flood in 1692 which had not been equaled up to 1765. (Smith's History, Chap. XII.) This is said to have been due to the melting of snow. Another great flood occurred in 1786, the height of which is recorded, and of which we estimate the volume at Lambertville to have been 175,000 cubic feet per second. In 1801, 1836 and 1839 there were floods reaching from 140,000 to 150,000 cubic feet per second. On January 8th, 1841, a disastrous flood occurred which reached 255,000 cubic feet per second. June 8th, 1862, there was another of about 224,000 cubic feet per second. Other floods since 1841 have not reached as high a point as that of 1862. There is certainly nothing in these records which clearly indicates any progressive increase in the volume of floods, but it appears to be true that the number of floods of from 150,000 to 175,000 cubic feet per second are more frequent than they were formerly. The history of this stream is important, because deforestation on the large portions of the catchment lying in Pennsylvania and New York continued down to a more recent date than in New Jersey.

On the Raritan there have been four great floods during the century, namely, those of November 24th, 1810, July 17th, 1865, September 24th, 1882, and February 6th, 1896. So near as we have been able to ascertain, the flood of 1810 and that of 1882 were of very nearly equal volume, while that of 1865 was a little lower, and that of 1896 was considerably higher than any of the others. Bearing in mind that deforestation was progressive on the Raritan up to about 1860, but has not increased since that time, it is clear that here also there is no evidence that deforestation has been accompanied by an increase in the height of floods. The same is true of the Passaic, on which there is no record of a higher flood than that of September, 1882.

We have investigated also the lowest reported heights of the Delaware since 1831, and these seem to indicate that the least flow was recorded in September, 1881, but this is accounted for by the fact that the droughts occurring in 1880 and 1881 were the severest of which we have any record in the rain-fall during this period, but we are disposed to think that the evidence points to a greater prevalence of low stages during the last half of the century.

EFFECT IN EQUALIZING THE DISCHARGE OF STREAMS.

In the foregoing we have spoken of the extreme stages of the rivers, and we have called attention to these because it may be attempted to show from such records the effect of forests. Our experience is that this cannot be done, but that the real benefit appears in the shorter periods of low water and the smaller number of floods. This is an effect of greater economic value, because the extreme stages are not of frequent occurrence. Thus on the Passaic river, during seventeen years, a rate of 24 cubic feet per second per square mile was reached only once and lasted only about three hours, while the lowest rate of flow of .19 cubic feet per second per square mile was reached only two or three times for a few days in each case, whereas the stream stood at stages between .4 and 1.34 cubic feet per second per square mile an average of 112 days yearly, and between 1.34 and 3.35 cubic feet also an average of 112 days during each year. It is evident, therefore, that what would be really of importance on the Passaic would be a cause affecting these stages of the river. It is in those stages which prevail during six months of an ordinary dry period that we believe the benefits are most felt. The soil and sub-soil of a catchment hold in storage a large amount of water, which is fed out to the streams in the form of springs and seepage during dry periods. It is a matter of common observation that at such times rivers continue to flow when the rain-fall is very much less than the evaporation, and, indeed, for many days when there is no rain-fall at all. Anything which tends to increase this amount of water held in the ground, and to regulate its discharge to the streams, tends to give a larger dry-season flow and to shorten the periods of very low water, and with this increased capacity of the ground to absorb rain comes also less frequent floods. Humus in the forest forms a great sponge and of itself holds a large amount of water, and, together with the inequalities caused by tree-roots, etc., tends to prevent the water flowing over the surface, while the roots of the trees provide ready channels for percolation into the subsoil. Consequently, forests will absorb a much larger amount of rain than either barren or cultivated country.

Cultivation undoubtedly has a tendency to increase the capacity of the ground to absorb water, because of constant loosening of the surface and the facilities provided for ready drainage. In this way cultivation, like forests, tends to make floods less frequent; but the effect of under-drainage is that the ground-water absorbed is usually fed out more rapidly to the streams during the early months of a dry season than is the case with forests, consequently the ground-water is sooner exhausted and the duration of the low stages of the rivers is longer. Barren watersheds offer the least capacity for the absorption of the rain-fall. There is no humus or other matter on the surface to retain the water, and the ground becomes hard and resists free percolation.

The effect of cultivation in increasing the flow of springs has been frequently remarked through the West, where tillage has followed barren conditions. We have some testimony in this State to the same effect where cultivation has succeeded forests. At a meeting of the New Jersey State Board of Agriculture, January 17th, 1900, the following statement was made by Mr. Emmor Roberts, of Moorestown, a member of the Board of Managers of the Geological Survey, during a discussion of this subject: "In my early boyhood I listened to old men talking about certain streams having been dry in years past. They told me that some seventy-five years ago they were all dry in the summer time. I thought about it, and I thought it was reasonable that it should be so; that the land was in timber then, while it is all clear now. It looked to me reasonable that, the lands now being tilled, the rain that falls goes through the soil to the under-drains and into the streams, which run abundantly the whole year through. I interviewed all of the old mill-owners and every one I ever knew and approached on that subject always said, 'My stream is better now than it was when I was a boy.' That was the uniform answer I got from every mill-owner I approached." This seems to indicate that on the level, sandy, or loamy lands of Southern New Jersey cultivation may increase the flow of the springs.

We believe that the usual difference between forested and cultivated water-sheds is very well illustrated by the Passaic and Raritan respectively, while some of our small red sandstone water-sheds are good types of barren country. In the following table we have contrasted these three types, the data being taken from the Report on Water-Supply of 1894. This table shows in inches of rain-fall the amount of water which would drain out of the ground to the several streams, from their water-sheds, each month during a drought of such a character that the rain-fall is just equal to the evaporation, so that the effect of both rain-fall and evaporation upon the streams is for the time suspended.

These figures are the result of a computation based upon actual gaugings. The gaugings themselves show a similar result, but cannot be so accurately compared owing to variations in the rain-fall on the different water-sheds.

Yield of Springs on Various Types of Water-Sheds During Drought.

IN INCHES OF RAIN-FALL.

MONTH.	Passaic, Type of forested water-shed.	Raritan, Type of highly cultivated water shed.	Type of barren water shed.
First month, ...	1.16	1.43	.94
Second month, ...	.54	.64	.38+
Third month, ...	.40	.45	.26
Fourth month,	.33	.35	.20
Fifth month, ...	.32	.30	.14
Sixth month, ...	.31	.27	.12
Seventh month, . . .	.30	.25	.10
Eighth month, . .	.29	.23	.08
Ninth month, ...	.28	.22	.07
Total, ...	3.93	4.14	2.29

It will be observed that while the Raritan and the Passaic show nearly the same total amount of drainage, the Raritan gives up this water faster in the early months, and, therefore, its springs become sooner exhausted and it runs lower toward the end of the drought. The barren ground, having absorbed much less water, has less flow from springs throughout. How important this is upon the dry-season flow of these streams becomes apparent from the following table:

Computed Run-off, in Gallons, Daily per Square Mile, During the Last Eight Months of 1881.

	Passaic.	Raritan.	Barren
	Forested.	Cultivated.	Water-sheds.
April,	597,000	754,000	631,000
May,	297,000	325,000	145,000
June,	272,000	272,000	139,000
July,	207,000	134,000	22,000
August,	140,000	89,000	22,000
September,	139,000	87 000	23,000
October,	129,000	84 000	22,000
November,	127,000	93,000	23,000

The economic importance of this effect lies in the greater value of forested streams for water-power, and the smaller storage reservoirs needed thereon to furnish a given daily supply of water to cities. Illustrative of this, the Passaic will furnish for 9 months of the year, from 100 square miles of water-shed, 45 horse-power on 10 feet fall, whereas the Raritan will furnish but 41 and the barren water-shed 28 horse-power. During the other 3 months the Passaic will furnish an average of 36, the Raritan 32, and the barren water-shed 20 horse-power.

To collect 570,000 gallons of water daily on one square mile of water-shed we shall need storage reservoirs of the following capacity: Passaic, 84,000,000; Raritan, 110,000,000, and barren water-sheds, 126,000,000 gallons.

The difference in cost of collecting a supply at the above rate per square mile, therefore, upon the type of streams selected to represent the forested and upon those representing the barren conditions, would be about $8,400 per square mile. Both the Passaic and Raritan exceed 800 square miles in catchment. For such an area the saving would be $6,720,000.

Taking the same size of catchment we find the excess of water-power on the forested stream would be, for 100 feet fall, 1,360 horse-power, the value of which, at a rental of $35 per horse-power per annum, would be $47,600, or the interest at 5 per cent. on $952,000.

We do not advance these figures as exact measures of the value of forests, but they may be taken as indicative of the possible financial loss which might result in stream-flow alone from deforesting such of our water-sheds as are not adapted for cultivation.

It will also be seen how amply this effect of forests in increasing the stream-flow for five or six months, during the latter part of a dry period, explains popular opinion as to a falling-off of streams when the forests are cut off. Such an effect is very much more likely to impress itself upon the popular mind than an increase of evaporation, which would tend to decrease the total run-off for the year without being very apparent to ordinary observation. Being a much more enduring effect, it would also be more noticeable than any change in the greatest or least rate of discharge.

We may illustrate the effect of the great absorptive capacity of forests in diminishing floods by comparing the run-off of the forested Passaic and deforested Raritan during the dry period in 1892, during which period both streams were being measured. This run-off, together with the rain-fall month by month, is shown in the following table:

	Passaic.		Raritan.	
1892.	Rain.	Run off.	Rain.	Run off.
June.	4.68	1.20	4.06	1.60
July,	3.27	.52	4.11	.57
August,	4.39	.53	3.61	.47
September,	2.17	.40	2.75	.31
October,	.72	.25	.32	.24
November,	6.84	1.38	6.99	2.18

It will be seen the rain-fall conditions were very similar; during the dry months, from July to October, inclusive, the run-off on the Passaic was 1.70 inches, and on the Raritan 1.59 inches. While the run-off before August was greater on the Raritan, during the following three months it declined to a considerably lower point. During November rains were abundant on both catchments, and of these rains 1.38 inches ran off on the Passaic, and 2.18 inches, or nearly 60 per cent. more, on the

Raritan. The same effect is noticed on several other streams, and while it is not always easy to determine whether it is due to the forests or to differences of soil and sub-soil, it appears to be true that the forested catchments generally show about the relative superiority in absorptive power over those largely deforested that is shown by the Passaic over the Raritan. Again, during the four years from 1890 to 1893, inclusive, there were on the Raritan thirteen floods exceeding 8,000 cubic feet per second, one of which reached 23,746 cubic feet per second, while on the Passaic during the same time there were but five such floods, and the highest reached only 11,701 cubic feet per second, while the rain-fall on the two streams shows no corresponding difference.

On the Delaware the more frequent occurrence of floods since 1835 has been pointed out in a report by Professor Mansfield Merriman, printed in Appendix U—XIX of the Annual Report of the Chief Engineer, U. S. Army, for 1873. (See, also, Report on Water-Supply, 1894.)

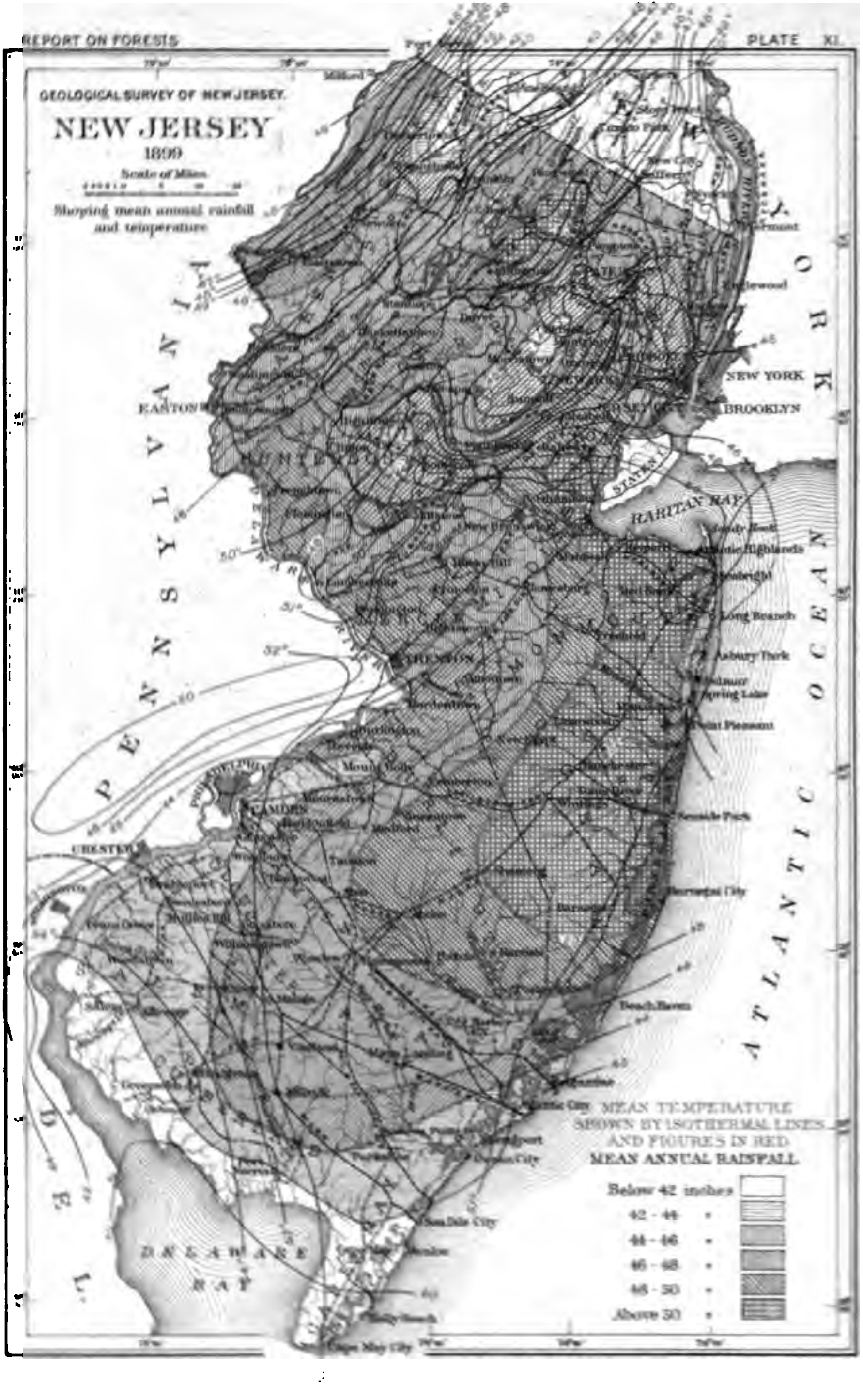
EFFECT ON THE PURITY OF THE WATER.

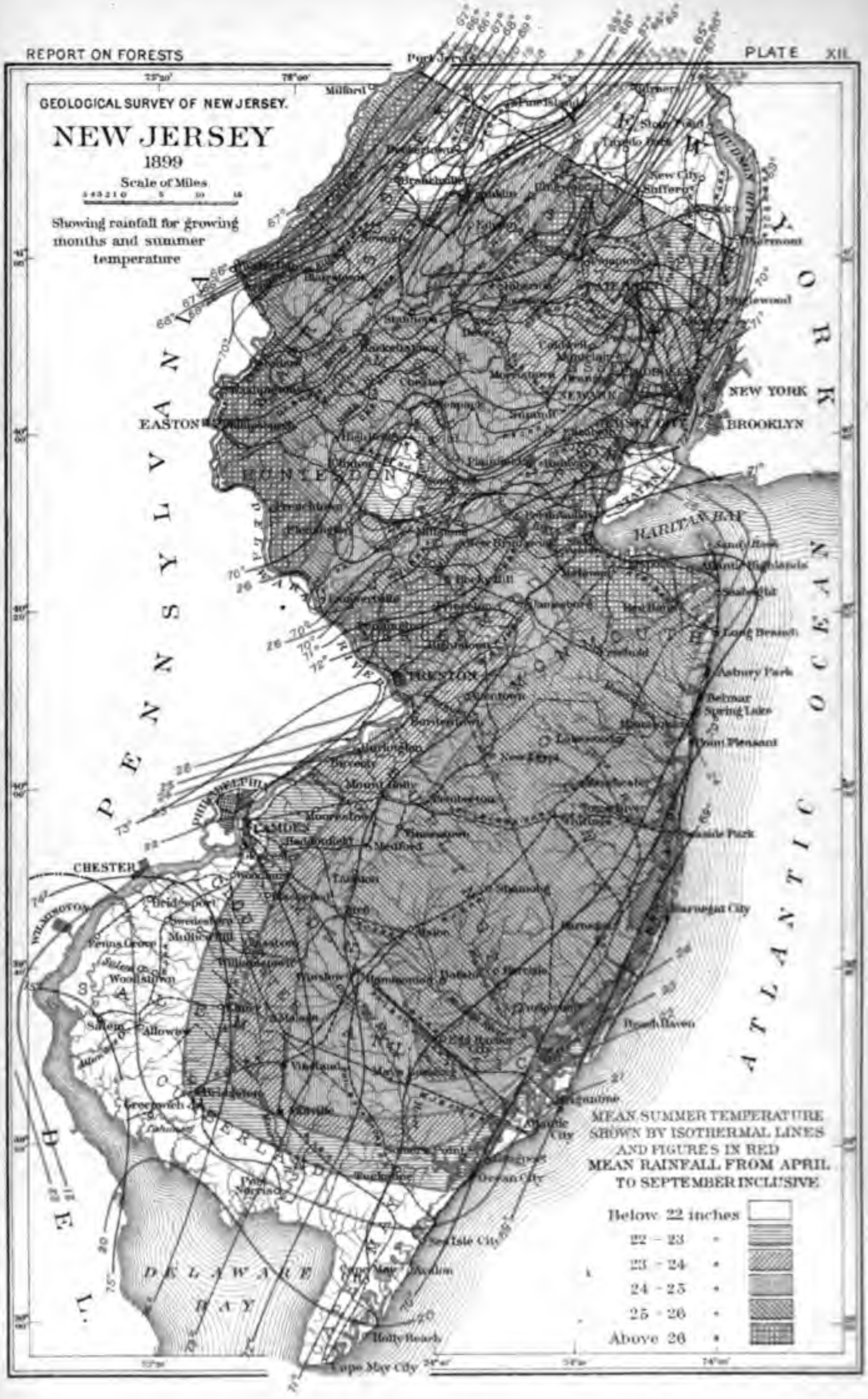
It is not easy to prove by analysis or statistics any effect of forests upon the quality of the water in the streams. It must be borne in mind that extensive forests are always attended by a scanty population, and for this reason the waters are usually superior in quality, but it is a matter of common observation that the amount of sediment carried is much less upon a forested stream than when the catchment is under cultivation. The difference in this respect on our red sandstone streams is especially noticeable. On the cultivated portions the amount of mud carried in suspension is very large, but where the catchment is well protected with forests it is much less.

The same fact may be observed if we compare the well-forested Highlands streams, such as the Pequannock, Rockaway and Ramapo, with those in the more cultivated portions of the Highlands, such as the Musconetcong and the head-waters of the Raritan. From observation, we are disposed to think that water of the best quality is obtained when the slopes and the higher lands of the catchment are covered with forests, while from 20 to 30 per cent. of the area in the valleys and along the stream channels is cleared of trees and in grass. The vegetable matter in the water will be less for such conditions than when the entire catchment is covered with forest. Such are about the conditions which obtain on the Northeastern Highlands streams already referred to.

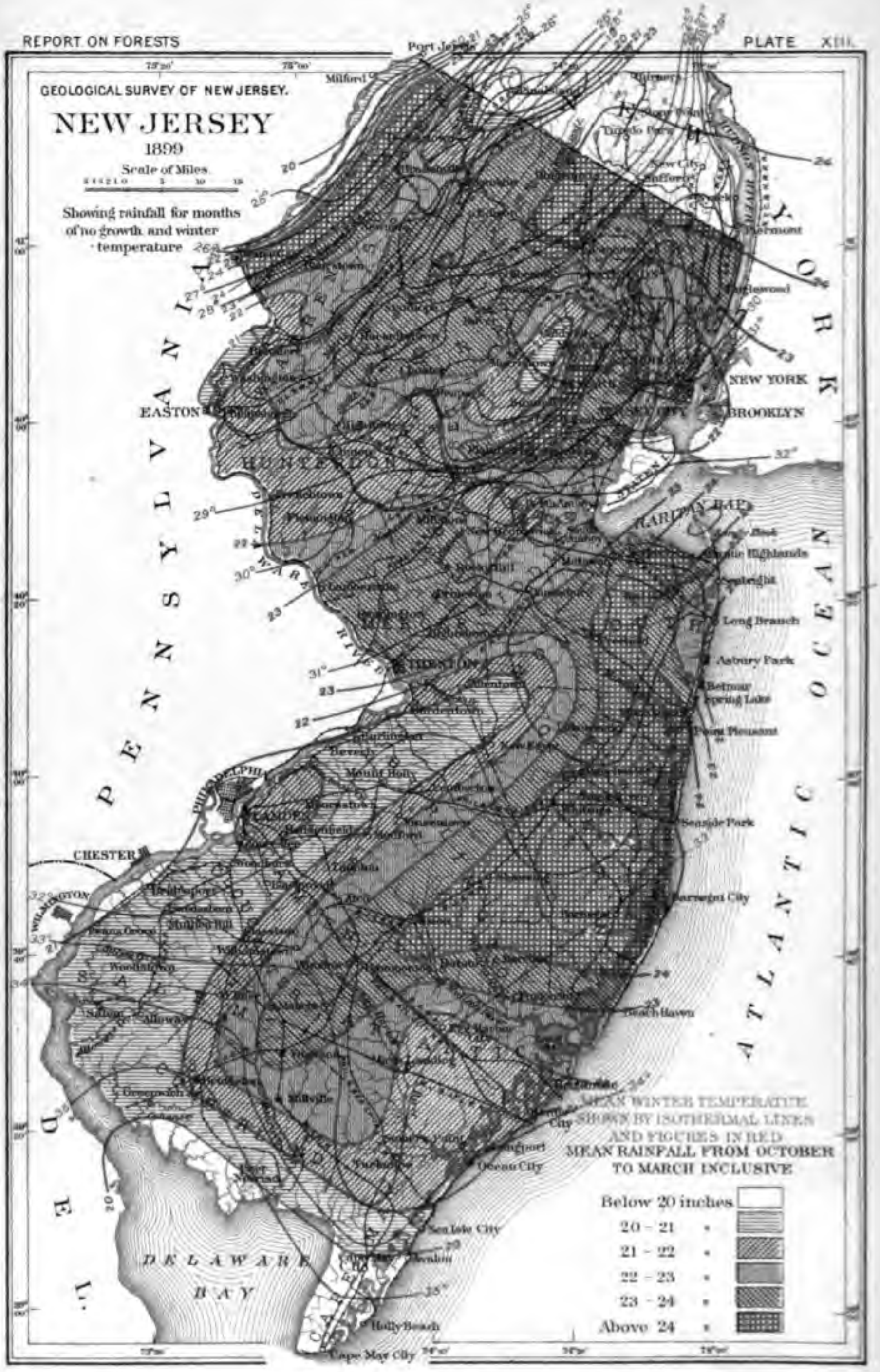
For hygienic reasons, therefore, as well as in order to preserve a steady and uniform discharge, it becomes very important that the forest cover shall be protected and preserved upon the catchments which are to become gathering-grounds for the cities of the State.

PLATE XI.


GEOLOGICAL SURVEY OF NEW JERSEY.
NEW JERSEY
1899
Scale of Miles.
Showing mean annual rainfall and temperature
NEW YORK
BROOKLYN
EASTON
CAMDEN
CHESTER
TRENTON
HUNTERDON
MERCER
STATEN
RARITAN BAY
Sandy Hook
Atlantic Highlands
Long Branch
Asbury Park
Spring Lake
Point Pleasant
Seaside Park
Barnegat City
Beach Haven
Atlantic City
Sea Isle City
Cape May City
P E N N S Y L V A N I A
N E W   Y O R K
A T L A N T I C   O C E A N
D E L A W A R E   B A Y
D E L.
50°
51°
52°
MEAN TEMPERATURE SHOWN BY ISOTHERMAL LINES AND FIGURES IN RED
MEAN ANNUAL RAINFALL
Below 42 inches
42 - 44 "
44 - 46 "
46 - 48 "
48 - 50 "
Above 50 "


GEOLOGICAL SURVEY OF NEW JERSEY.
NEW JERSEY
1899
Scale of Miles
Showing rainfall for growing months and summer temperature
MEAN SUMMER TEMPERATURE SHOWN BY ISOTHERMAL LINES AND FIGURES IN RED
MEAN RAINFALL FROM APRIL TO SEPTEMBER INCLUSIVE
Below 22 inches
22 – 23 "
23 – 24 "
24 – 25 "
25 – 26 "
Above 26 "
PENNSYLVANIA
NEW YORK
ATLANTIC OCEAN
DELAWARE BAY
DEL.
HUNTERDON
MONMOUTH
HUDSON RIVER
RARITAN BAY
DELAWARE RIVER
Port Jervis
Milford
EASTON
NEW YORK
BROOKLYN
TRENTON
PHILADELPHIA
CAMDEN
CHESTER
WILMINGTON
Morristown
Plainfield
New Brunswick
Freehold
Long Branch
Asbury Park
Belmar
Spring Lake
Point Pleasant
Lakewood
Mount Holly
Moorestown
Medford
Burlington
Bordentown
Bridgeton
Salem
Woodstown
Greenwich
Millville
Vineland
Hammonton
Atlantic City
Ocean City
Sea Isle City
Cape May City
Holly Beach
Barnegat City
Beach Haven
Tuckerton
Englewood
Dover
Newton
Lambertville
Flemington
Hightstown
Pemberton
Absecon
Egg Harbor City
Sandy Hook
Atlantic Highlands
Sea Bright
Red Bank
Penns Grove
Mullica Hill
Allowaystown
Port Norris
Glassboro
Williamstown

REPORT ON FORESTS PLATE XIII.



Forests and Climate.

The influence of forests upon climate has been extensively discussed, but it cannot be said that definite conclusions have been reached. It appears to be true that aridity has resulted in some cases from cutting off the forests, but that this is not a necessary result appears to be proven from experience in England and Spain. The former has only about 3 per cent. of its area in forests, yet it continues to be proverbially fertile, and a land of abundant moisture and luxuriant vegetation. Spain also retains its moisture and fertility in spite of deforestation.

Perhaps it is safe to conclude that where other strong influencing conditions are absent, the effect of forests may be appreciable. Thus it has been pointed out that the lower temperature, which sometimes prevails over a forest, may cause greater condensation and consequently increased precipitation. It seems, however, that this difference of temperature does not usually exceed two or three degrees, and consequently would be equaled in effect by a ridge about 600 feet in height, so that where the topographic relief is bold enough its influence may entirely subordinate any effect of forests upon the rain-fall or temperature. In like manner the influence of the sea upon temperature and rain-fall may be so controlling that the effect of forests becomes of little account. This is true in England, and it appears to be also the case in this State.

It may be accepted as a fact that the temperature immediately over a forest is sometimes a few degrees cooler than over the open country. It is no doubt true that the temperature beneath the trees is materially less and the humidity somewhat greater.

To determine what the effect of forests may be in our own State, we have compiled the accompanying charts of rain-fall and temperature from the records of New Jersey State Weather Service, and from all other data accessible. In making up these charts all short-period stations have had their record referred to, and compared with those of long periods in such a way that the differences due to comparison of periods not contemporaneous are eliminated as far as possible.

Plate XI shows the mean temperature for the year, and the mean annual rain-fall. This may be compared with Plate III, showing the distribution of forests. At first sight it appears as if the regions of heavy rain-fall coincide with those of abundant forests, while the deforested areas along the Delaware and in the Raritan valley show a light rain-fall; but on closer examination we find that the rain-fall in the pine forests varies from about 52 inches at Toms River to less than 40 inches at Cape May, without any corresponding change in forest conditions. The variation in the cleared belt of the Cretaceous formation along the Delaware is nearly as much, or from about 42 inches at Salem to over 50 inches in Monmouth county. In the same way the rain-fall of the Kittatinny valley ranges from 40 inches to over 48 inches, the whole being deforested to about the same extent, while the Passaic valley, having over 40 per cent. of forest, appears to have as small a rain-fall as the Raritan valley, where there is less than 5 per cent. of forests. A careful study of the annual rain-fall indicates that topographic relief has an effect entirely superior to that of the forests, and we are forced to the conclusion that it is impossible to trace any effect either upon rain-fall or temperature due to the distribution of the forests.

The temperature seems to be influenced largely by the sea, and to a still more marked extent by the elevation; and studying the rain-fall and temperature together it appears that the storms which usually occur with easterly winds show a more abundant precipitation as such winds approach or cross high ground, and a lighter precipitation in the valleys west.

Plate XII shows the summer temperature, and the mean rain-fall from April to September inclusive, these being the growing months for forests. This plate is made up with a view to ascertaining the influence of forests when they are in leaf. Here, also, it is impossible to detect any difference in the distribution of rain-fall which may be fairly attributed to forests. In general the same peculiarities which we have pointed out in the annual rain-fall are present here. There is the same wide variation in rain-fall in belts of country having uniform forest conditions.

The light rain-fall of the Raritan valley is somewhat accentuated, but in the Highlands it appears that the deforested portions have as much rain-fall as those more heavily forested. The influence of the sea upon the temperature in summer is marked, while the variations due to elevation, in the northern part of the State, are much the same as shown in Plate XI for the year.

Plate XIII exhibits the winter temperature and the rain-fall from October to March, inclusive. In this case the rain-fall presents a distribution a little different from that of the growing months, but, comparing the two periods, there is nothing to warrant the inference that it is in anywise effected by forests.

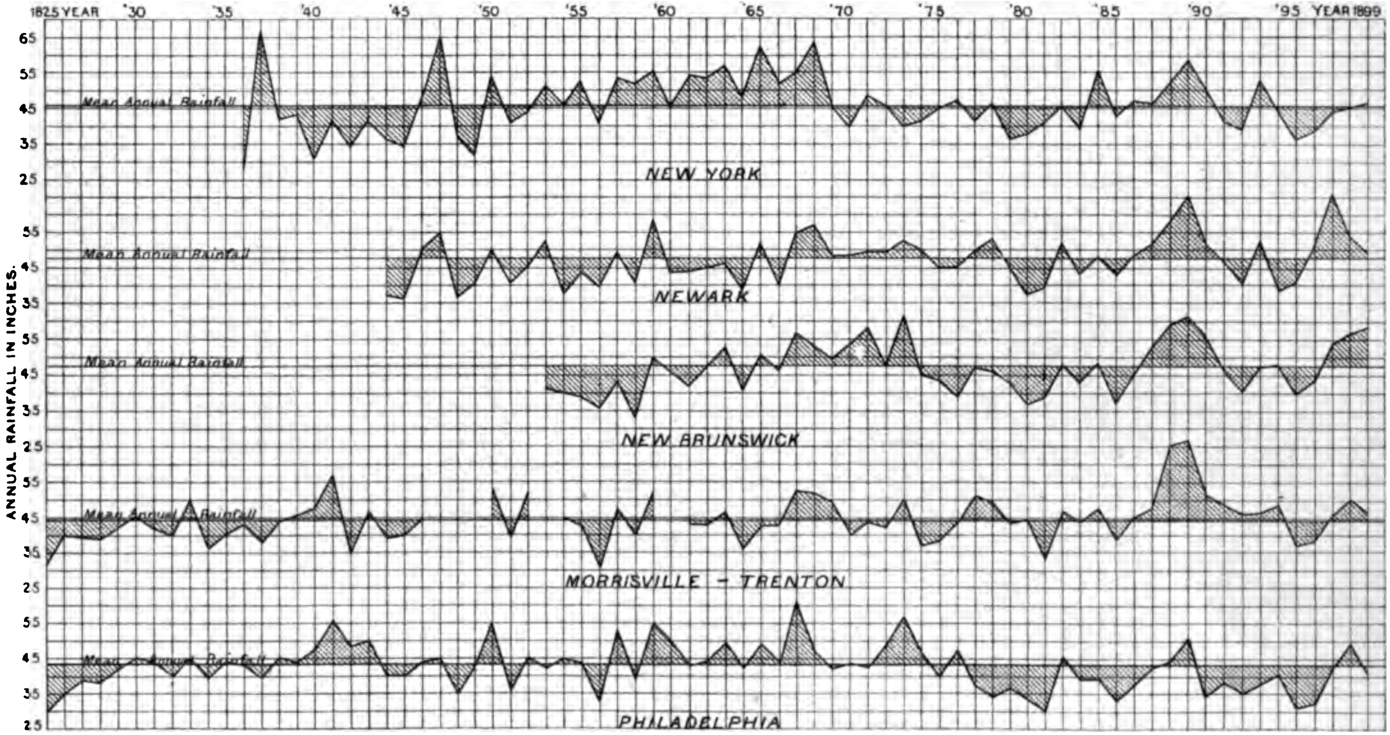
The result of these studies must be regarded as demonstrating that the records of rainfall and temperature fail to show any difference in climate between forested and deforested portions of the State which may with confidence be ascribed to the influence of the forests.

We have also analyzed the longer rain-fall records of the State, and of New York and Philadelphia, to see if there has been any change in the rain-fall which may be due to change in the forests. Plate XIV is a series of diagrams showing the rain-fall at New York, Newark, New Brunswick, Trenton and Philadelphia. The Trenton record is combined with one at Morrisville, Pennsylvania, just across the Delaware. The Philadelphia record goes back to 1825, and so does the Morrisville-Trenton record, although the latter is missing for certain years. The New York record begins with 1836, that of Newark with 1843, and that of New Brunswick with 1854. New York is so much within the influence of the ocean that it can scarcely be expected to show any effect due to forests, but this fact makes the record valuable for comparison with the stations more inland. The diagrams show that from 1836 to about 1868 the rain-fall at New York was steadily increasing, but at the latter date it suddenly fell off and remained below the average until 1883, since which year it has been fluctuating. The Newark record is very similar to that of New York, while the New Brunswick, Trenton and Philadelphia records vary in certain particulars from the other two, principally in showing larger rain-fall from 1868 to 1873. It will be seen that, as a rule, rain-fall was increasing at Newark and New York, while deforestation was progressing in the northern part of the State. We have stated that this deforestation was at a maximum from 1850 to 1860, and while the rain-fall at Newark and New Brunswick may have been somewhat below the average during those years, it certainly was not less in either the New York, Philadelphia or Morrisville records than it was earlier, and it was more in the Philadelphia record than it was from 1825 to 1835. On the other hand the period of droughts extending from 1869 to 1883 at New York and Newark, and from 1874 to 1885 at New Brunswick, Trenton and Philadelphia, occurred after the forests had begun to grow again, and had improved materially in the northern part of the State. But taking a rather wide radius around Philadelphia there has been, on the whole, progressive deforestation at a slow rate up to the present time; that is, the forest area has decreased. The Philadelphia record for the entire period of seventy-five years shows no corresponding diminution in the amount of rain-fall.

Indeed, it has been pointed out in Bulletin D, of the U. S. Weather Bureau, that there has been a general tendency to increased rain-fall in New England from 1834 up to the present time. We have examined the long record at Troy, New York, and this shows the same characteristics that we have pointed out in the diagrams of New York and Philadelphia rain-fall, namely, a progressive increase of rain-fall from about 1839 to about 1870, with wide fluctuations since the latter date.

The following table shows the result of grouping and averaging the rain-fall of New York, Newark, New Brunswick, Trenton–Morrisville and Philadelphia, by five-year periods:

Years.	Average Annual Rain-fall.
1825–1829,	37.52
1830–1834,	41.32
1835–1839,	42.50
1840–1844,	44.33
1845–1849,	42.78
1850–1854,	46.00
1855–1859,	44.53
1860–1864,	45.81
1865–1869	49.16
1870–1874,	48.05
1875–1879	43.63
1880–1884,	42.04
1885–1889,	49.50
1890–1894,	45.75
1895–1899,	46.16



SECULAR CHANGE IN ANNUAL RAINFALL.

This table is believed to show quite accurately the changes of rain-fall in New Jersey, taken as a whole, during the last seventy-five years, and the tendency to progressive increase from 1825 to 1869, with only minor fluctuations, is apparent. It is also evident that the rain-fall is greater during the last half of this period. Thus, during the quarter century from 1825 to 1849, the average is 41.69 inches, while for the next twenty-five years, to 1874, it is 46.71 inches, and for the last quarter century it is 45.42 inches. The showing of these records is clearly against the hypothesis that deforestation is accompanied by a decrease of rain-fall, because there was correspondingly greater deforestation during the quarter century from 1850 to 1874 than during the previous quarter century, while the rain-fall was more than five inches greater. In the same way, taking the State as a whole, there was certainly as much forest during the last quarter century, from 1875 to 1899, as during the previous one, although the average rain-fall is 1.3 inches less. The other rain-fall records of the State are too short to enable us to draw safe conclusions.

Turning to the temperature records, we find that the Philadelphia record goes back to 1790, and from this date up to 1820 the temperature is below the average, while it ranges somewhat above from 1820 to 1830. There is another low period from 1830 to 1840, after which time it continues generally above the average until 1884, reaching another minimum in 1885. During the whole period there is undoubtedly an upward tendency in the temperature of Philadelphia, but it is difficult to draw safe conclusions from a comparison of the early and later records, owing to a difference in instruments and methods. We do not find in the records of temperature anything from which safe conclusions may be drawn as to the effect of deforestation in the State. Unquestionably the temperature of Southern New Jersey is affected much more by the sea than by the pine forests, but our personal experience is to the effect that the mild and salubrious winter climate of this region is to a great extent due to the presence of the pine forests and the sandy soil, which together produce an unusually dry atmosphere for a climate which is so much influenced by the sea. We believe that the entire destruction of these pine forests would result in a much less favorable winter climate, and would produce a desert of drifting sand, which would be shunned by all. There is no difficulty in noting present differences of climate in winter between the cleared and forested portions of Southern New Jersey, and probably these differences are of a nature which affects bodily comfort more than the records of the thermometer, as they are largely due to the wind and moisture in the air. We cannot doubt that if this sandy soil should be deprived of forest cover it would quickly lose all vegetable matter, and would become extremely hot in summer. We refer especially to those portions which consist of silicious sands and are unadapted for cultivation.

The point may be raised that while the figures of annual and average rain-fall show nothing as to the effect of forests, there may be a difference of distribution, so that the fluctuations may be greater and the droughts more severe in a forested country. Of this we can find no evidence in the New Jersey weather records. A careful study of these records indicates that all parts of the State, whether forested or deforested, are about equally subject to periods of drought, and that the severity of the droughts, as measured by the rain-fall during the dry period, varies with the average rain-fall, or, in other words, those parts of the State which are shown on our charts to have a large average rain-fall have a correspondingly larger dry-period rain-fall. The severity of the drought as measured by its effect on vegetation, however, is greater in those portions of the State where temperature and, consequently, evaporation are greater. Thus the Highlands and Kittatinny valley do not suffer so severely from drought as the more southern portions of the State, principally because evaporation is less.

Unquestionably, forests have a marked effect in retarding the melting of snow in the spring, and on this account it is possible that owing to their presence the spring will be somewhat later and cooler in a forested country than in the open.

PART II.

The Relation Between Forestry and Geology in New Jersey.

I. Existing Conditions.

II. Historical Development.

By ARTHUR HOLLICK.

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK,
DEPARTMENT OF GEOLOGY, December 14, 1898.

Professor John C. Smock, State Geologist of New Jersey:

DEAR SIR—I have the honor to submit herewith my final report upon the Relation between Forestry and Geology in New Jersey, based upon investigations pursued under your direction during the past two years.

Respectfully, &c.,

ARTHUR HOLLICK, Ph.D.

The Relation Between Forestry and Geology in New Jersey.

CONTENTS.

I. Existing Conditions.
- Object and Scope of this Report.
- Method of Investigation Pursued.
- Facts Ascertained.
- Discussion of the Facts.

II. Historical Development.
- Preliminary Discussion.
- Mesozoic Time.
  - Triassic Period.
  - Jurassic Period.
  - Cretaceous Period.
- Neozoic Time.
  - Tertiary Period.
  - Quaternary Period.
- Concluding remarks.

I. Existing Conditions.

OBJECT AND SCOPE OF THIS REPORT.

The problems of plant distribution, or, in other words, the reasons why certain classes, families, genera or species of plants occupy certain regions, have long received attention from those who have observed the facts. If the earth as a whole be viewed in connection with the entire vegetable kingdom, it is at once apparent that the most obvious factor in limiting distribution is climate, and that isothermal lines are closely identified with lines of plant limitation. If smaller geographic areas and smaller aggregations of plants be studied, however, it will at once be seen that climatic conditions alone are not sufficient to account for all the facts of distribution and limitation which may be observed, and that local physiographic and meteorologic influences must be considered, such as altitude, minor surface inequalities and configurations, presence and absence of moisture in the atmosphere, presence of or proximity to water, &c. Finally, if the investigations be carried yet further, it will be appreciated that soil characteristics, both mechanical and chemical, also play an important part in the matter. This source of influence may be termed the geologic factor, for the reason that the character of the soil in any locality is directly dependent upon the character of the geologic formation from which it is derived, and it is with this factor that this report is especially concerned.

It is unfortunate that by far the greater number of areal investigations which have been undertaken have necessarily been restricted by artificial boundaries, generally political, such as state or county lines, instead of having been extended to their natural limits, either physiographic or geologic, and many interesting problems for this reason have been only indicated or partially solved. The investigations upon which this report is based fall within the same category, and there is no doubt that if these could be carried out beyond the state lines, whatever value they may have would be enhanced in proportion to the distance or area covered.

In the state of New Jersey, for example, two broad, contrasting regions of forest conditions have long been recognized, viz.,

---

NOTE.—In order that the meaning of certain terms may be clearly understood, the following definitions are appended:

Distribution may be defined as geographic range. Thus, "Middlesex and Mercer counties, southward to Cape May," would represent a geographic range or area of distribution. A species may have a wide distribution and yet be rare, for the reason that it may only be able to exist under conditions which obtain in but few localities within the area of distribution.

Locality or *Station* defines some particular place. Thus, "Middlesex county, near Perth Amboy," would represent a locality or station.

Habitat means character of surroundings. Thus, "rocky hillsides," "salt marshes," "dry, sandy soil," &c., would be habitats.

A *typical species* of any region or area is one which is either confined to such region or area, or which only extends beyond it in limited numbers or under specially favorable circumstances.

A *characteristic species* of any region or area is one which is so abundant as to be a prominent feature over such region or area, although not necessarily confined to it.

the Deciduous and the Coniferous; and the contrast between the two is so obvious as to attract the attention of every observer.* Doubtless to many the fact that the former is roughly confined to the hilly northern part of the state and the latter to the plain region further south, might seem sufficient to account for the limitation of the two classes of vegetation simply on climatic and physiographic conditions. If, however, the line of demarkation between them be followed across the state, or better yet, if it be followed beyond the confines of the state, it may be seen that it does not coincide with any parallel or latitude or any isothermal line, but crosses these in a northeast and southwest direction, and is more or less independent of surface irregularities.

If, now, a geologic map of the state be examined, the line of demarkation may be seen to parallel very closely the general trend of the outcrops of the geologic formations, and the inference becomes irresistible that these must be taken into account in any investigations which concern the problem of forest distribution in the state. Investigations were therefore made from that point of view, and as they proceeded the fact became more and more apparent that not only were the two classes of vegetation strongly identified with certain geologic formations, but also that the distribution of several species in each of the classes were similarly limited.

This line of investigation is capable of extension so as to include a far larger number of species than were actually brought under observation, and there is no doubt that if the entire flora of the state could be mapped, from the same standpoint, an exceedingly interesting contribution would result. If, further than this, the investigation could be made to cover the entire geographical area comprised within the areas of distribution, the interest and possible value of the work would be correspondingly increased. Such an investigation would, however, imply many years of careful study in the field, and all that can be attempted in this report is to outline the known facts of distribution in regard to certain species of trees in the state and to draw from those facts such conclusions in regard to the probable causes as may seem to be warranted.

---

* For a brief discussion of the subject see Dr. N. L. Britton's "Catalogue of Plants Found in New Jersey," introductory chapter, Final Report State Geologist, Vol. II, 1889.

METHOD OF INVESTIGATION PURSUED.

The general facts as previously indicated having been recognized, steps were taken towards a detailed investigation by traversing the state in a series of routes more or less at right angles to the trend of the geologic formations, thus crossing the outcrops in succession and noting whatever changes in vegetation were apparent from place to place. Several critical localities were also made the subjects of special investigation. Following are the routes traveled and special localities visited:

1. Jersey City to Deckertown. Triassic, Archæan, Ordovician, and Silurian formations, including the region covered more or less with glacial drift.

2. Jersey City to Easton, Pa. Same formations as in No. 1, but south of the Terminal Moraine.

3. Jersey City to Stroudsburg, Pa. Same formations as in No. 1, with Devonian additional.

4. Jersey City to Allamuchy, via Sparta and Waterloo. Same formations as in No. 1, but further south.

5. Monmouth Junction, beginning at Ten-Mile Run, via Jamesburg and Freehold to Farmingdale. Triassic, Cretaceous and Tertiary formations.

6. Lakewood to South Amboy, via Farmingdale, Eatontown, Red Bank and Matawan. Tertiary and Cretaceous formations.

7. Point Pleasant to Burlington, via Lakewood, New Egypt and Mount Holly. Tertiary and Cretaceous formations; complete section through the state.

8. Bound Brook to Perth Amboy, via New Brunswick. Triassic and Cretaceous formations.

9. Metuchen to Perth Amboy. Triassic and Cretaceous formations, Terminal Moraine and extra-morainic drift.

10. Camden to Cape May. Cretaceous, Tertiary and Post-Tertiary formations. A special object in visiting the latter locality was to investigate the report that *Pinus Tæda* L. (old-field Pine) had been found there. The result was that its occurrence there was verified and a new species was added to the flora of the state. A full account of this discovery was published in *The Plant World*, Vol. I, No. 2 (Nov., 1897), which

was subsequently republished in *The Forester*, Vol. III, No. 12 (Dec., 1897).

11. Matawan to Old Bridge, via Robertsville and Texas. Cretaceous clay marl and clay. Distribution of *Pinus echinata* Mill (Yellow Pine), and *P. Virginiana* Mill (Scrub Pine).

12. Freehold to Red Bank, via Scobeyville. Cretaceous and Tertiary marls. Occurrence of *Pinus Strobus* L. (White Pine).

13. Morristown and vicinity. Triassic trap and sandstone, Archæan and Terminal Moraine.

14. Trenton and vicinity. Glacial and recent river gravels.

15. Holly Beach and Anglesea. Sand dunes and salt marshes.

16. Asbury Park and vicinity. Buried forests in recent sea-beach deposits.

17. Belvidere and vicinity. Terminal Moraine and extra-morainic drift.

18. Delaware Water Gap to Bushkill. Influence of the Delaware river in modifying or extending the range of certain species.

19. Newark and vicinity. Salt marshes, with special reference to the occurrence of *Taxodium distichum* (L.), L. C. Rich (Bald Cypress). This is apparently the only locality in the state where this tree is known to be in existence independent of cultivation. The trees are few in number and are accompanied by several specimens of *Chamæcyparis thyoides* (L.), B. S. P. (White Cedar). I was, however, unable to determine whether they were native there or had been introduced. The trees appear to be about twenty or thirty years old and are growing in salt marsh—a habitat such as they naturally occupy further south. Several reports have been made of old cypress stumps having been found in swamps in other parts of the State, but in no instance have I been able to verify them.

20. Bridgeton. Tertiary (Miocene?) sandstone containing fossil leaves. The occurrence of this fossil flora may be found discussed in the chapter on the historical development of the flora of the state.

FACTS ASCERTAINED.

If an irregular line be drawn, extending from a little east of Metuchen to Trenton, and a similar one from Long Branch to

Salem, the typical deciduous region or zone will be found to lie north of the former and the typical coniferous zone south of the latter, while between the two is an area about sixteen miles wide which may be termed the "tension zone," because it is there that the two floras meet and overlap, producing a constant state of strain or tension in the struggle for advantage. *

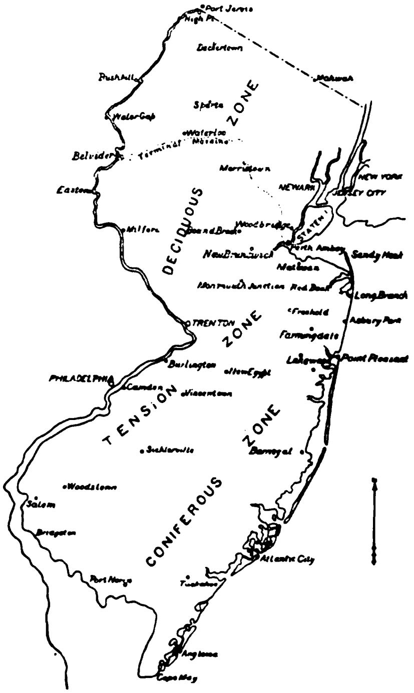


Figure 1. Map showing Forest Zones

Within the limits of either the deciduous or the coniferous zone the conditions are more or less uniform; the typical or characteristic species of each have become firmly established in the environment most favorable for them, or unfavorable for others, and the struggle for advantage is largely between individuals of the same species. In the tension zone, however, the struggle is not only between individuals of the same species, but also between different species. The elements in the deciduous flora are always ready to seize upon any advantage which will give them a foothold further south, while the elements in the coniferous flora are always ready for an advance in the opposite direction. The former may, therefore, be considered as a southward-moving and the latter as a northward-moving flora.

---

* An excellent general discussion of floral tensions may be found in Mr. Conway MacMillan's "Metaspermæ of the Minnesota Valley," pp. 594-600. Repts. Geol. and Nat. Hist. Surv. Minn., Botanical Series, Vol. I. 1892.

In consequence of these conditions the vegetation in the tension zone is in a state of unstable equilibrium, in which the strain is constant, and any change in or interference with the conditions releases the strain and causes a disturbance of the relations between the floras until new conditions have become established. Each such disturbance is marked, to a greater or less extent, by changes of species, and lines or areas of limitation and distribution thus vary from time to time.

The influence of civilization has been the most marked factor in this connection in recent times. Fire and cultivation have caused, directly and indirectly, great changes in the interrelations of species. In places certain species have been removed for economic purposes and others allowed to remain, which, of course, gives a direct advantage to the latter in any subsequent struggle for place. In other localities all species have been removed and such a change made in the environment that foreign species, better able to adapt themselves to the new conditions, become established there.

One corollary to the above proposition is that changes wrought within the limits of the deciduous or coniferous zones would not normally lead to such extensive subsequent changes in species as would be the case under similar circumstances within the limits of the tension zone.

In the deciduous zone, for example, where clearings have been made, these are often occupied at once by pines and cedars, which have been awaiting the opportunity to establish themselves where they will be free from competition. The soil favors their growth, but they are almost always crowded out subsequently when the angiosperms regain their foothold, and the ultimate result is practically a return to the old conditions, due to the higher and more aggressive type of life represented by the latter.

In the coniferous zone also the same species would be likely to re-appear after a tract has been cleared, for the reason that the soil conditions are usually barren and unfavorable for the angiosperms, which type of plants would only be represented in consequence by stunted weaklings.

In each of these cases the original species would also have the direct advantage that their own relatives would be in the preponderance in the immediate neighborhood, and therefore be the first to reproduce their kind in any numbers. In the case of the tension zone, however, any change, no matter how insignificant, might afford just the advantage which some opposing species of either zone required for its establishment in neutral territory.

For this reason the former lines of specific limitation in the tension zone it is now impossible to determine. In this zone the changes have undoubtedly been the greatest, as it is there that cultivation has been the most extensive, and over miles of the surface, in the marl belt especially, the original forest has been completely destroyed, while in the other zones the limits and relative proportions of the species have probably always remained about the same.

Another corollary to which it may be of interest to call attention is that where zones of vegetation become established by reason of the conditions being directly favorable in each, the weaker individuals are necessarily crowded to the front and meet in the tension zone. Where, however, a zone becomes established, not because the conditions are directly favorable for the vegetation which occupies it, but only indirectly for the reason that it is unfavorable for any other, this condition may result in bringing stronger individuals to the front of the more barren zone and into the tension zone.

This is well exemplified in the case of *Pinus rigida*, which is usually larger where it occurs in isolated groves in the better soil of the tension or deciduous zones than in its normal location in the sand barrens.

This fact, considered by itself, would appear to give a decided advantage to the coniferous vegetation, but its lower position in the biologic scale, as compared with the deciduous, is evidently more than sufficient to offset this advantage.

In the following enumeration an attempt is made to give an idea of the general character of the forest in each zone, by listing the most conspicuous and abundant species in each.*

---

* The nomenclature adopted is that of Britton & Brown's "Illustrated Flora of the Northern United States, Canada and the British Possessions."

DECIDUOUS ZONE:

Gymnospermæ: *Pinus Strobus* L., *Tsuga Canadensis* (L.) Carr., *Juniperus Virginiana* L.

Angiospermæ: *Juglans nigra* L., *Hicoria ovata* (Mill.) Britton, *Hicoria glabra* (Mill.) Britton, *Hicoria alba* (L.) Britton, *Carpinus Caroliniana* Walt., *Betula lenta* L., *Fagus Americana* Sweet, *Castanea dentata* (Marsh.) Borkh., *Quercus Prinus* L., *Q. rubra* L., *Q. coccinea* Wang., *Q. velutina* Lam., *Q. alba* L., *Ulmus Americana* L., *Liriodendron Tulipifera* L., *Platanus occidentalis* L., *Cornus florida* L., *Rhododendron maximum* L., *Fraxinus Americana* L., *F. Pennsylvanica* Marsh., *F. lanceolata* Borck.

Scattering from the Coniferous Zone: *Chamæcyparis thyoides* (L.) B. S. P., *Pinus rigida* Mill., *Diospyros Virginiana* L., *Ilex opaca* Ait.

CONIFEROUS ZONE:

Gymnospermæ: *Pinus rigida* Mill., *P. echinata* Mill, *P. Virginiana* Mill., *Chamæcyparis thyoides* (L.) B. S. P. Angiospermæ: *Quercus Phellos* L., *Q. nigra* L., *Q. minor* (Marsh.) Sarg., *Q. alba* L., *Q. coccinea* Wang., *Q. velutina* Wang., *Magnolia Virginiana* L., *Cratægus uniflora* Muench., *Prunus maritima* Wang., *Ilex opaca* Ait., *Diospyros Virginiana* L.

Scattering from the Deciduous Zone: *Pinus Strobus* L., *Tsuga Canadensis* (L.) Carr., *Castanea dentata* (Marsh.) Borkh., *Hicoria alba* (L.) Britton, *Liriodendron Tulipifera* L.

SPECIES MORE OR LESS ABUNDANT IN BOTH ZONES: *Populus tremuloides* Michx., *Salix nigra* Marsh., *Betula nigra* L., *Betula populifolia* Marsh., *Alnus rugosa* (Du Roi) K. Koch., *Quercus nana* (Marsh.) Sarg., *Sassafras Sassafras* (L.) Karst., *Liquidambar Styraciflua* L., *Prunus serotina* Ehrh., *Acer rubrum* L., *Nyssa sylvatica* Marsh.

It may be noted that three species (*Quercus alba*, *Q. coccinea* and *Q. velutina*) are listed as characteristic trees in both zones. This means that they are so abundant in both that any description of the prevailing vegetation in either would be incomplete unless they were mentioned. On the other hand, the species listed as abundant in both zones are equally wide in their distribution, but none of them is so abundant as to be characteristic, being more or less scattered, usually following minor surface conditions, such as water-courses, swamps, fence lines, &c.

Doubtless in certain sections other species than those above listed would appear equally important as elements in the flora, but those enumerated will give a fair idea of the arboreal features as a whole. If a complete census of all the species which inhabit each zone be made, and studied, it will be found that the deciduous zone contains the greater number and diversity, and that, as a rule, they are well mixed; no one species forming the bulk of the forest over any considerable area. In the coniferous zone, on the contrary, the monotonous uniformity of the forests, due to extensive aggregations of a few predominant species, is often conspicuous over hundreds of square miles. In the latter zone, for example, *Pinus rigida* is not only the predominant but almost the exclusive species, over large areas, but no such example can be quoted in regard to any one species in the deciduous zone. This species also occurs in several scattered groups northward in the state, but not in sufficient numbers to form forests or to be classed as characteristic of the deciduous zone.

If now the geology and topography of each zone be considered it may be seen that the southern limit of the deciduous zone is quite sharply coterminous with the southern edge of the Triassic outcrop, and that it extends unrestricted in all other directions up to and beyond the state line and that its geologic and topographic features are exceedingly varied. The coniferous zone, on the contrary, is coterminous along its northern border with the northern border of the Tertiary sands and gravels and presents but little diversity either in its geology or topography, except for the fringe of sand beaches and salt marshes at tidewater, by which it is limited in the east and south. Its area is restricted by these barriers in these directions, but it extends beyond the boundary of the state southwestwardly. The tension zone, which includes practically the whole of the Cretaceous plastic clays and the Cretaceous and Tertiary clay marls and marls, is intermediate, geographically and in its geologic and topographic features, between the other two.

The above-mentioned facts may be observed to advantage in a number of critical localities, as, for example, in the vicinity of

Farmingdale. Here there is an area of marl which is located well within the borders of the sands and gravels. If a line be traversed, starting from the vicinity of Lakewood, in the heart of the coniferous zone, little else than *Pinus rigida*, *P. echinata*, *Q. alba*, *Q. velutina*, etc., are met with, until the border of the marl area is reached, when the pines disappear and in their stead are deciduous trees, amongst which may be noted *Quercus rubra*, *Hicoria alba*, *Ulmus Americana*, *Populus tremuloides*, *Castanea dentata*, *Liquidambar Styraciflua*, *Betula nigra*, etc. As soon as the opposite border of the area is crossed the conditions are reversed and pines are again predominant until the edge of the main marl belt is reached near Eatontown, where deciduous trees again prevail. The lines of demarkation which may be noticed in thus crossing from one formation to another are so sharply defined by the character of the vegetation in each as to be plainly apparent within a small fraction of a mile.

If the same area be crossed in a direction about at right angles to the previously mentioned route, beginning in the deciduous zone near Monmouth Junction, an equally significant series of facts may be noted. In this vicinity the trees are almost wholly deciduous, consisting largely of *Quercus rubra*, *Q. alba*, *Q. velutina*, *Hicoria alba*, *H. glabra*, *H. ovata*, *Ulmus Americana*, *Fraxinus* sp?, *Fagus Americana*, *Castanea dentata*, *Liriodendron Tulipifera*, *Liquidambar Styraciflua*, *Populus tremuloides*, *Carpinus Caroliniana*, *Platanus occidentalis*, *Acer rubrum*, *Cornus florida*, etc., with occasional groups or individuals of *Juniperus Virginiana* and *Pinus Strobus*, all of large size and vigorous growth.

In traveling across the clay belt toward Jamesburg several of the above-mentioned species may be noted as becoming less prominent or as disappearing entirely, while those which continue are noticeably smaller in size. Several new species also make their appearance, such as *Diospyros Virginiana*, *Quercus ilicifolia*, *Q. nigra*, *Pinus Virginiana and P. rigida*, and this condition of the vegetation prevails until well within the borders of the marl belt near Englishtown, when the trees again become somewhat larger in size. This variation in the size of the trees was in most cases found to be coi[illegible]dent [illegible]th the presence or absence of areas of sand or gr[illegible] occurring in connection with such areas, which latter were also coincident with the distribution of several of the species. In one locality, about a mile north of Englishtown, the road passes through quite a deep cut, in a sand hill of considerable extent laterally and vertically. On this hill is a conspicuous growth of *Pinus rigida* and *Diospyros Americana*, although they seem to be entirely absent elsewhere in the immediate vicinity. Continuing on towards Freehold, some of the species which were but sparsely represented before may be noted as becoming more prominent, and then a marked change occurs as soon as the border of the marl belt is crossed. In place of an almost universal deciduous vegetation, patches of *Pinus rigida* become conspicuous features until the marl area at Farmingdale is reached, when the pines disappear and are not again met with until the area is crossed. By this route it may be seen that the entire width of the tension zone is crossed, where the relations of the two floras are most complicated.

Another interesting locality is the vicinity of Perth Amboy, where the Terminal Moraine extends southward beyond the Triassic border, and encroaches for a short distance onto the Cretaceous area. The deciduous flora, which elsewhere is coterminous with the Triassic border, is here carried beyond, to the edge of the Moraine, where it is in sharp contrast with the coniferous trees of the tension zone, which here find their most northern limit in the state.

At many other localities in or near the tension zone similar facts may be noted, but the above instances are probably sufficient for purposes of illustration.

As examples of the areal distribution and limitation of species the following may be taken as specially interesting:

Tsuga Canadensis. More or less abundant in the deciduous zone, especially in hilly regions along the borders of streams. Not recorded south of the tension zone, except indefinitely, as very rare, in Monmouth and Ocean counties. New Egypt, Vincentown and Burlington are the only exact localities known to me south of the Triassic border, and these three localities are all within the tension zone.*

Pinus Strobus. Frequent in the deciduous zone, often forming good sized groves. Represented in the tension zone by scattered individuals or limited aggregations, especially along water-courses. Almost limited to scattered individuals in the coniferous zone. The probabilities are that the species was formerly more abundant in the tension zone than the present distribution indicates. It is the characteristic pine of the deciduous zone.

---

* NOTE BY STATE GEOLOGIST: Reported, below Sharptown, on Salem creek, Salem county, a grove of thirty large trees. Charles R. Lippincott.

Pinus rigida. Exceedingly abundant in the coniferous zone, where it often forms the bulk of the arboreal vegetation over large areas. Less abundant in the tension zone. Represented by scattered groves or individuals in the deciduous zone. It is the characteristic pine of the coniferous zone.

Pinus Virginiana. Abundant in the tension zone, especially in the clay belt. Less abundant in the coniferous zone, but frequently forming small forests or groves. Recorded from the deciduous zone only at widely separated localities—Riegelsville, Milford and New Brunswick.

Pinus echinata. Most abundant in the tension zone, particularly in the marl belt, often forming groves of considerable extent. Less abundant in the coniferous zone and not recorded from any locality within the deciduous zone. This and the preceding species may be regarded as specially characteristic of the tension zone.

Chamæcyparis thyoides. Forms the bulk of the vegetation in the cedar swamps of the coniferous zone. Rare in the tension zone. Locally in limited numbers in certain isolated swamps in the deciduous zone: Secaucus, New Durham, High Point, etc.

Rhododendron maximum. Abundant in the deciduous zone, often forming dense thickets along streams and lake borders. Recorded from but one locality in the tension zone, in the vicinity of Burlington and Kinkora, and from but one in the coniferous zone, at Sicklerville.

Ilex opaca. Common in wet woods, especially near tide-water, in the coniferous zone. Less abundant in the tension zone. Reported from but one locality in the deciduous zone, at Carpentersville.

Quercus Phellos. More or less abundant in the southern part of the state in both the coniferous and tension zones. Further north, especially abundant in the clay belt of the latter zone, where it occurs close to the edge of the Triassic border, but has not been recorded beyond.

Quercus nigra. Practically the same range as the latter.

If the above defined areas of distribution and lines of limitation be studied it will at once be apparent that they are not due to climatic conditions. In the case of *Chamæcyparis* we have a species which exists as far north as Massachusetts and as far south as Florida, while *Pinus rigida* is known from Canada to Georgia—their occurrence north of the coniferous zone being apparently largely due to locally favorable physiographic conditions.

Considering other species we may even eliminate physiographic conditions as a cause of distribution, as, for example, *Quercus Phellos* and *Q. nigra*, which extend northward in the eastern part of the state as far as Perth Amboy, but in the western part are not known north of Trenton. A line drawn between these two localities defines their limit of distribution. The topographic features for a large part of the distance along both sides of this line are practically identical, and yet neither of the species crosses it. The fact which is at once apparent, however, is that this line is coincident with the line which separates the Cretaceous and Triassic outcrops, and the rational inference is that this feature, the geologic, is the important one to be studied.

In the instances quoted the coincidence between the geologic features and the areas of distribution and lines of limitation are more striking than in most cases, as they were chosen specially for that purpose, but there is no doubt that a careful tabulation of similar facts in regard to other species would be exceedingly interesting and significant.

DISCUSSION OF THE FACTS.

If the foregoing facts be carefully considered, one feature in connection with them will at once attract attention by reason of its constant reiteration. This is the influence apparently exerted by certain geologic formations upon the distribution of certain classes or species of trees, or, for the sake of argument, the coincidence which apparently exists between certain geologic formations and certain facts of plant distribution, and from whatever point of view we may regard the matter it finally resolves itself into an examination of the soil conditions which are directly dependent upon the structure and composition of the geologic formations from which they were derived. Soil influence is indicated in all the before-mentioned facts of plant-distribution within the state as one of the most potent factors, and in some instances as practically the only one to be taken into consideration. Here it seems pertinent to remark, lest the fact should not be thought of, that the mere name which any geologic formation may bear is of no consequence in this connection. The only matter of moment is its lithologic characters, mechanical or chemical, irrespective of age or stratigraphic position. A sandy soil, whether a recent dune deposit or one derived from the disintegration of Palæozoic sandstone in place, would be of equal importance so far as sand-loving plants are concerned. Similarly a heavy soil, whether of glacial till or Cretaceous marl, might be equally available as a home for species which must love such a mechanical condition for their proper growth, while those which merely require a rocky soil would be indifferent as to whether the rock was Eozoic granite or Mesozoic trap.

This line of argument, as may be readily seen, infers that the mechanical structure of the soil is of greater importance as a factor in plant distribution than is its chemical composition, and this seems to be the fact. The observations made indicate that the former is the more powerful factor in determining the original location and distribution of species, while the latter more largely influences their subsequent growth.

Upon this basis of reasoning we may in part account for the fact that species of the deciduous zone, where the soils are comparatively rocky or heavy, are able to push their way southward into the clays and marls of the tension zone, and we also note the effect of the chemical composition of the soil on their growth, as indicated by their decrease in size wherever the same species occur, on areas of sand or gravel within the zone. By a similar course of reasoning we may understand the northward extension of species from the coniferous zone, such as *Pinus Virginiana*, on account of the sandy or gravelly surface-soil which prevails over most of the tension zone, and its abrupt limitation where this ceases. *Quercus Phellos* and *Q. nigra* are, without doubt, limited in their distribution by the same cause, and we are justified in assuming that if the soil conditions, or, what is the equivalent, the geological formation in which they grow, had a further northward extension, the species mentioned would be found upon it.*

When the chemical characteristics of the soil of each zone are studied, it becomes easy to understand why the vegetation in each is so different. In the deciduous zone the rocks are partially weathered and disintegrated for a considerable depth, and this disintegration is unceasingly going on, constantly adding new material to the soil from the variety of the mineral constituents in the rocks. New soil is constantly being made and the old soil being renovated, so that plant food is in process of manufacture all the time. The mechanical character is also such that it is capable of retaining moisture for a considerable period, which is a valuable factor in periods of drought.

On the other hand, in the coniferous zone the rock has long been almost completely disintegrated, and as it is practically composed of but one constituent, quartz, which is of little or no value for plant food, any further disintegration is incapable of yielding any other element, and but little is added to the soil which could serve to support vegetation. Further than this, in many places no rock disintegration is going on, but, on the contrary, rock is in actual process of formation. Sandstones and conglomerates are being formed by cementation with limonite, and where this occurs a hard layer results which limits the downward growth of roots, while if the conditions are such that an open, porous sandy soil prevails, it becomes impossible for water to be retained in it, and an arid sand barren is the result.

One thing, however, as previously hinted, should be borne in mind in regard to many typical or characteristic species, which is that they do not always exist in a region by reason of the environment being the most favorable for them, but because the environment may be unfavorable for other species. Thus, to again refer to the case of *Pinus rigida*, while it exists in parts of the sand barrens of Ocean, Burlington and Atlantic counties, almost to the exclusion of all other trees, it is stunted and conpicuously less vigorous in appearance as a whole than where it occurs as scattering groves or individuals in richer soil further north. The natural inference is that it would exist to better advantage in a different soil, but that other, more agressive species, higher in the biologic scale, are able to seize upon and hold such soils against it, and that it exists in the pine barrens largely by reason of freedom from competition. This inference is further strengthened if we consider its wide geographic range, as previously noted, which includes a great diversity of soil and climate.

---

* In this connection the following reference may be found of interest:

1. "On the Existence of a Peculiar Flora on the Kittatinny Mountains of Northern New Jersey." N. L. Britton. Bull. Torrey Bot. Club, Vol. XI (1884), p. 126.

2 "Plant Distribution as a Factor in the Interpretation of Geologic Phenomena, &c." Arthur Hollick. Trans. N. Y. Acad Sci. Vol. XII (1893), p. 189.

The relation between these existing facts and the events which preceded them will be discussed in the next section.

II. Historical Development.

PRELIMINARY DISCUSSION.

In tracing the development of plant life through geologic time the fact is well recognized that the flora of Eozoic and Palæozoic times is not related to our living flora by any closer ties than those of sub-kingdoms or classes. In Mesozoic time generic relationships may be traced, while in Neozoic time many species identical with, or closely related to, living ones, may be identified.

It is also accepted, as a broad generalization, that biologic development has been synchronous with the stratigraphic sequence, or, in other words, that the older the geologic formation the lower in organization are its accompanying fossils, and conversely that the more recent the geologic formation the higher in the scale of life are its fossils.

In palæobotany the facts in this latter connection are particularly striking and provide us with excellent data from which to draw conclusions. Plant life was evolved into its present status largely through the influence of changes in environment, and changes now under way are modifying it still further. In order therefore to understand how any particular living flora has reached its present condition it is necessary to know something about the changes, in their proper sequence, which the region has undergone in the past.

Within the boundaries of the state are geologic formations representing all the great time divisions, Eozoic, Palæozoic, Mesozoic and Neozoic, and rocks of all the included geologic periods, with the exception of Carboniferous and Jurassic, but for the purposes of this report the vegetation of Palæzoic time may be disregarded.

MESOZOIC TIME.

Triassic Period. During this period the shore line of the North American continent, so far as New Jersey is concerned, extended irregularly from about the vicinity of Mahwah to a few miles south of Phillipsburg. Everything indicates that for a long time the Atlantic border had been slowly sinking and that the Triassic deposits were laid down in estuaries and lagoons which were alternately covered by the tides and exposed to the air. The rocks are largely conglomerate, sandstone or shales, evidently shore or shallow-water deposits, often ripple-marked or sun-cracked and bearing the footprints of reptiles or amphibians.

The vegetation of the period is but sparsely represented in the collections which have been made in New Jersey, but by comparing these with similar collections from other places it may be seen that the vegetation is fairly representative of the period. Dr. J. S. Newberry has described nine species from the state,* of which three are regarded as pteridophytes, and the remainder are apparently all referable to the gymnosperms. One living genus (*Equisetum*) is recognized in the former subkingdom.

Thus far, in any collection of Triassic plants which has been made, nothing higher in biologic development than the monocotyledons is even indicated, and we may regard the Triassic flora as one composed almost wholly of ferns and their allies, cycads and conifers, with cycads as the dominant type.

---

*"Fossil Fishes and Fossil Plants of the Triassic Rocks of New Jersey and the Connecticut Valley." Monographs of the U. S. Geol. Survey, Vol. XIV.

Jurassic Period. Towards the close of the Triassic period great physical changes occurred, of which the extrusion of trap dykes was one of the prominent features. The indications are that that portion of the continent now represented by New Jersey and vicinity was raised to a higher level than further south, for the reason that in this region we find no deposits which can be recognized as Jurassic, while deposits which may be provisionally considered as such occur in Maryland and southward. In New Jersey, therefore, we have a break in the geologic sequence at this point, and in consequence a hiatus in the line of plant development, which, however, has been at least partially bridged by Professor Wm. M. Fontaine * and Dr. Lester F. Ward, † in their studies of the Potomac formation of Maryland. The exact geologic age of the lower strata of this formation has not been definitely determined, but the evidence thus far adduced from the fossil plants indicates a transition from the Triassic flora below to the typical Cretaceous flora above. In this transition flora, accompanying the numerous pteridophytes and gymnosperms, are many archaic types, mostly of undoubted angiosperms, in which generic relationships with living plants are more or less definitely indicated under such names as *Ficophyllum*, *Sapindopsis*, *Saliciphyllum*, *Quercophyllum*, *Eucalyptophyllum*, &c. A number of living genera are also recognized, such as *Torreya*, *Sequoia*, *Araucaria*, *Taxodium*, *Sassafras*, *Ficus*, *Myrica*, *Sterculia*, &c. The number of pteridophytes and gymnosperms, compared with the angiosperms, is about 4 to 1. The comparatively limited number of modern elements contained in the flora renders any comparison with our living flora somewhat hazardous, so far as any conclusions as to the probable climatic conditions are concerned, but we may safely say that in its general characters tropical or sub-tropical conditions are indicated.

Cretaceous Period. As previously stated, Jurassic strata are wanting in New Jersey, and we find that those which next succeed the Triassic are clays, sands and gravels of Middle Cretaceous age. This indicates a later submergence of the New Jersey area, when the shore-line was approximately where we now find the northern edge of the clay belt to be, extending from Woodbridge to Trenton. This was evidently a period of quietude and slow subsidence, as the deposits indicate, during which immense quantities of land vegetation were entombed, many of the specimens so delicate that it is difficult to understand how they could have been preserved, affording additional evidence of the quiet conditions which must have prevailed. This flora has been described by Dr. Newberry,* who recognized in it 156 species, of which all but about 30 are angiosperms, nearly all of them included under living genera.

---

* "The Potomac or Younger Mesozoic Flora." Monographs of the U. S. Geol. Survey, Vol. XV.

† "The Potomac Formation." 15th Ann. Rept. U. S. Geol. Survey, pp. 307–397.

Many of these are genera which now inhabit the region, such as *Diospyros*, *Juglans*, *Liriodendron*, *Magnolia*, *Populus*, &c., but others are of foreign or more southern indigenous distribution, such as *Bauhinia*, *Cinnamomum*, *Eucalyptus*, *Ficus*, *Laurus*, *Passiflora*, *Sequoia*, &c.

No living species is recognized, although close specific relationship is indicated in one of the names adopted (*Magnolia glaucoides*) and is commented upon in regard to others. The most significant feature as a whole is the complete reversal of the proportions between the angiosperms and gymnosperms when compared with these proportions in the preceding formation, the angiosperms being now overwhelmingly in the ascendant. The genera also indicate a climate less tropical than that which preceded it.

After the clays had been laid down, as estuary or brackish water deposits, as indicated by the occurrence of marine molluscs in limited numbers, the submergence continued, and we next find the clay marls, representing a transition to marine conditions. In these, as might be expected, the remains of land vegetation are less abundant, but apparently the flora was not noticeably different in its generic characters from that of the clays, although a number of new species may be noted. †

The subsidence continued and true marine conditions supervened. The marls were deposited and in them nothing but marine organisms are preserved. Thus far we have not found any record of the land vegetation which occupied the region during the time when this formation was being laid down, but in the West the conditions were different and the remains of Upper Cretaceous plants are abundantly preserved in the Laramie and allied formations. In these most of the Middle Cretaceous genera continue, but the species, in all except a few instances, are different. A large number of new genera make their appearance, including one entirely new type of vegetation —the fan palms—and for the first time the monocotyledons assume some prominence.

---

* "The Flora of the Amboy Clays." Monographs of the U. S. Geol. Survey, Vol. XXVI.

† See "The Cretaceous Clay Marl Exposure at Cliffwood, N. J." Arthur Hollick. Trans. N. Y. Acad. Sci. Vol. XXI, p. 124.

Generically it was more closely related to the living flora of the middle United States than was that which preceded it. The number of living genera included in it was actually and relatively greater and the species are of a more modern aspect, but none of the latter is apparently identical with any now in existence.

The ratios between the pteridophytes, gymnosperms and angiosperms were apparently approximately as we find them to be to-day, and the climatic condition indicated was warm-temperate.

NEOZOIC TIME.

Tertiary Period. During the early part of this period the indications are that while minor oscillations of level occurred, the previous era of subsidence continued until the shore-line advanced inland beyond the old Cretaceous border, covering the entire coastal plain with the deposits which we know in the aggregate as the Yellow Gravel formation. In places this is undoubtedly of marine origin, in others it is apparently due to floods of fresh water.

At one locality only, in the vicinity of Bridgeton, has the vegetation of any portion of this period been found within the borders of the state. Fortunately the remains there preserved were collected in considerable abundance and in an excellent state of preservation. Probably about fifty species are represented in the collections which have been made—all of them angiosperms, many of them referable to living species and some of them identical with species now growing in the vicinity of Bridgeton, such as *Ilex opaca*, *Nyssa sylvatica*, &c.[*]

A comparison between this fossil flora and the living flora of eastern North America indicates a close identity between the former and that now in existence at about the latitude of Virginia. In many of its elements it is unique and distinct from that of any other American Tertiary horizon. The collections of Eocene and Miocene plants which have been made in the West contain different species, and those from Bridgeton are either rare or entirely wanting in them. As a whole the flora is more nearly comparable with that of certain European Upper Miocene localities, and we may regard it as that which immediately preceded the close of the Tertiary period, and this conclusion is emphasized by the well-recognized fact that in Europe biologic evolution was in advance of America, so that the European Eocene flora is largely comparable with the American Miocene, European Miocene with American Pliocene, and European Pliocene with the American living flora.

On the whole I am inclined to consider it as more recent in age than that of any other recognized Tertiary horizon in America, but final conclusions in regard to it cannot be arrived at until a number of species collected during the progress of this investigation have been more critically examined.

Quaternary Period. Towards the latter part of the Tertiary period an era of elevation began, which raised the northern part of the North American continent hundreds of feet above its former level, and extended the shore-line far out beyond its former or its present position, so that the edge of the continent was about where we now find the 100-fathom contour to be, forming a broad expanse of coastal plain, extending out to this line. It was apparently the period of maximum land area for this region.

Up to this time in the world's history we have reason to believe

---

[*] The results of preliminary studies of this flora may be found in several papers by the writer, as follows:

1. "Palæobotany of the Yellow Gravel at Bridgeton, N. J." Bull. Torrey Bot. Club, Vol. XIX (1892), p. 330.
2. "New Species of Leguminous Pods from the Yellow Gravel at Bridgeton, N. J." *Ibid*, Vol. XXIII (1896), p. 46.
3. "A New Fossil Monocotyledon from the Yellow Gravel at Bridgeton, N. J." *Ibid*, Vol. XXIV (1897), p. 329.

In the above-quoted papers may also be found references to the work of others on the same subject that there were no such extremes of climate between the poles and the equator as prevail to-day. The temperature of the earth's surface had been more or less uniform during the respective periods, as evidenced by the fact that rocks of the same age the world over, wherever they have been examined, contain the remains of vegetation which are identical generically and even specifically to a large extent.

The elevation which began in the Tertiary period, however, caused, or at least was coincident with, the greatest changes, climatic and biologic, which are anywhere recorded in geologic history. The climate became gradually more and more severe at the north and finally culminated in what we have come to call the Ice Age or Glacial Epoch of the Quaternary period.

The change must have been a gradual one, extending over a long period of time, as we are justified in concluding from the fact that the vegetation which was in existence at the time when it was finally overwhelmed by the accumulation of ice and snow, which extended southward in New Jersey as far as Perth Amboy in the east and Belvidere in the west, was identical in all respects with that of to-day. In other words, the flora of the Tertiary period had had opportunity to become modified by the changing conditions before its final extermination by the ice sheet, which implies a long period of time. Every species thus far discovered in the bowlder till, in the glacial sands or gravels, or in buried swamp deposits, is identical with some living species. Some of the Tertiary species were able to continue their existence by migrating southward, and these are in existence to-day, but such as were unable to migrate from the area of glaciation were absolutely exterminated and only such species as were able to exist under the changed conditions southward were able to re-establish themselves after the final recession of the ice. I do not know of remains of the vegetation of this period having been found in New Jersey, and such as have been found elsewhere are scanty in amount, but all the species identified are the same as those now living.

CONCLUDING REMARKS.

The final recession of the ice was accompanied by a subsidence of the land and a consequent restriction in its area. The shore-line advanced inland, and in places only the more elevated parts of the coastal plain, where the morainal debris was heaped, remained above water. Such portions of the former plain region are now represented by Long Island, Block Island, Martha's Vineyard, Nantucket and the lesser islands in the vicinity. Several minor oscillations of level occurred, and finally the land assumed the contour and topography of to-day.

At the present time, so far as New Jersey and vicinity are concerned, a slow subsidence is recognized as taking place, which amounts to about two feet in a century. This rate of subsidence, while very slow compared with the activity of human events, is probably but little different from that which produced such far-reaching changes in the past. Indeed, its effects have been appreciable within historic time, and we have but to consider the cumulative effects which such a rate of subsidence will cause in time in order to appreciate that great changes, topographic and biologic, will be wrought in the future. Surveys have shown that the coast-line has advanced inland hundreds of feet in many localities since the land was first occupied by the whites. Old meadow-turf and tree stumps are to be seen in the ocean-bottom far out beyond the present shore, and what was once upland, capable of cultivation, has become converted into marshes.

Bearing all these facts in mind, it is certainly pertinent for us to speculate on what the ultimate result may be, provided the present conditions continue. Manifestly the flora which occupies the coast region will continue to have its habitat more and more restricted in area and will be driven more and more towards the tension zone, where the struggle for existence with its more highly organized neighbors will be fiercer. The history of evolution in the vegetable kingdom has shown conclusively that the gymnosperms represent a waning type and that the angiosperms have been steadily crowding them out. The former have decreased in numbers and in size, and in any competition for the occupancy of a region at all favorable for the angiosperms these latter are sure to prevail.

The general trend of events may be foreshadowed from what we have seen has taken place in the past, in the gradual waning of the more primitive gymnnosperm type and the coincident ascension of the more highly organized angiosperm type. The former now exists largely under barren-soil conditions towards the south, or under severe climatic conditions in the far north, not apparently by reason of these conditions being directly favorable for them, but, at least in part, for the reason that they are unfavorable for the angiosperms, which have crowded them out from the most desirable locations. The conclusion, therefore, seems to be inevitable that the flora of the coniferous zone is destined to be ultimately obliterated, or only to exist over limited areas, often for the negative reason that in such areas the conditions may not be favorable for other types of vegetation. The influence of man may produce temporary changes and give temporary advantage from time to time, but such changes are entirely artificial and cannot prevail in the long run over the constant and inevitable progress of physical and organic evolution.

PART III.

The Role of Insects in the Forest.

By JOHN B. SMITH,
State Entomologist.

The Role of Insects in the Forest.

By JOHN B. SMITH, Sc.D.

That a giant of the forest, one that has resisted the storms of a century, should succumb to the attacks of an insect, countless millions of which would be required to equal it in bulk, seems almost absurd; yet it is nevertheless true, though not, as a rule, quite so literally as it reads. Most of our forest trees support an immense insect population without showing any ill effects. Nearly 500 species are known to feed on the species of oak, and nearly 200 on the species of pine, in the United States. Given a perfectly healthy tree, it will bring to maturity a host of feeders upon its foliage, upon the smaller shoots, in the injured or broken twigs or branches, in its fruit, and even in its woody tissue. Comparatively few borers or other insects are able to maintain themselves in the growing wood of large healthy trees, and when these occur in moderate numbers they inflict only such wounds as are easily healed, corresponding to mere scratches in the human skin. Under some conditions these insects increase abnormally, and then thousands of acres of timber may be killed off. As the bleeding from many small scratches may drain the human body of blood when they are kept constantly open, so the boring of thousands of beetles, insignificant individually, may weaken even the forest giant; and when this occurs, when there is no longer a healthy, resistant tissue, then another host of other species steps in, adds to the injury, and paves the way for yet further armies that complete the work, leaving only a dead stick with bare branches, sooner or later prostrated by a storm, and then slowly reduced to dust by yet other agencies, insect, fungous, or microbic in character.

Of the feeders upon foliage in its broad sense, some, like caterpillars, feed openly and simply upon the leaf tissue, destroy and convert a certain amount of it into caterpillar tissue, and their work is done. Little impress is left upon the tree under ordinary conditions, or unless the feeding numbers are excessive. Even if one of the large species defoliates a branch, this is not serious except on conifers, which, on the whole, suffer less from attacks of this kind.

The larvæ of saw-flies are also feeders upon forest-tree foliage, and these sometimes do local injury. Saw-flies are Hymenoptera, *i. e.*, they belong with the bees, wasps and ants in structure; but they differ by having the abdomen closely joined to the body, not connected with it by a slender waist. Saw-fly larvæ resemble caterpillars in shape and appearance; but have at least 18 legs, instead of 16, as in true caterpillars. They have a tendency to feed in colonies and often curl up the end of the body when feeding at the edge of a leaf. A black-spotted species occurs on pine, sometimes in such numbers as to attract attention and defoliate even large branches. Small or ornamental trees in parks are sometimes killed or severely injured; but on larger trees a dead twig or small branch is the extent of the mischief caused.

Some of these larvæ are covered with a white powdery bloom, and at least one species, occurring on willow, becomes of considerable size, reaching an inch and a half in length when extended at full length. It is pale yellowish in general color, with a whitish, small head and a black stripe down the back, making it easily recognizable and a fair sample of this kind of larva except in size.

On the hickory and butternut other species occur that are known as "woolly worms," because of the masses of fine waxen threads that cover the body and give it a fluffy appearance.

Yet other species are gall-makers, causing blister or marble-like excrescenses on leaves, stems or twigs, in the center of which the larvæ feed. Willows and poplars are especially subject to this kind of attack.

Among the caterpillars, besides those that eat of the leaf tissue directly, many are leaf miners, eating between the upper and lower surfaces, sometimes irregular blotches, sometimes galleries of definite form, each species having a constant and characteristic type. A few others make little cases or sacks, in which they live and which they carry about with them. Many are leaf-rollers, folding or rolling the entire or part of a leaf into a cylinder, in which they feed under shelter. Yet others live in colonies and spin up a number of leaves or even an entire branch. The well known web-worms and tent caterpillars will readily occur to all, and wide-spread injury is sometimes done by one or both. The forest tent caterpillar has defoliated acres of forest land in New York State during the season of 1899, and has opened the way for yet more serious injury in 1900. Less known is another species that attacks young trees, often enveloping one of 4 or 5 feet completely. When this occurs the death of the young tree often follows, the growth being smothered where not actually eaten.

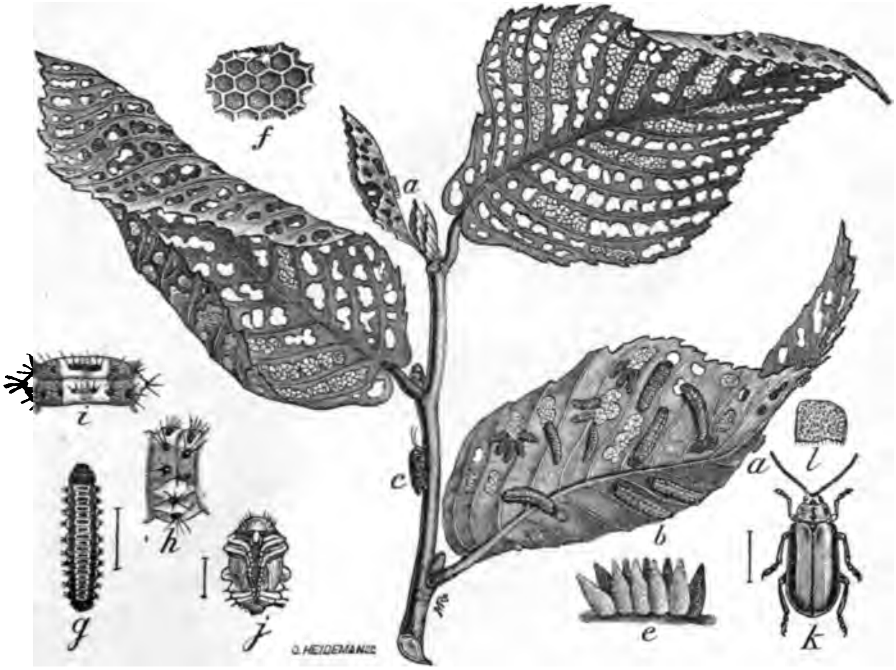


Figure 2.—Elm leaf beetle; typical of a destructive feeder on foliage: *a, a*, egg patches on leaves; *b*, larvæ feeding; *c*, adult; all natural size: *e*, egg-mass; *f*, surface of the egg; *g*, larva; *h, i*, details of the same; *j*, pupa; *k*, beetle; *l*, surface of elytra; all enlarged: from Div. Ent. U. S. Dept. Agl.

Numerous "grubs," or beetle larvæ, live on the leaves of forest trees, often in very large numbers, and these also may be open feeders, leaf miners or sac bearers; but they rarely become as destructive as the Lepidopterous and Hymenopterous larvæ already mentioned.

Galls made by saw-fly larvæ have been already mentioned; but they are in the minority when compared with those made by others of the same order Hymenoptera, the *Cynipidæ* or true gall wasps. These galls may appear on almost any part of the tree when young; but, when older, trunks and larger branches are exempt: and they are as diverse as the places they attack. Oaks are favorite subjects, but other trees are by no means free from them.

On the leaves the galls are usually more or less spherical or marble-like, but they differ much in size and texture, being sometimes quite solid with thick walls, sometimes filled with loose tissue and with a thin paper-like covering. Some are small and some are large, but that fact does not indicate the size of the larva that causes the gall. Two of the largest species occurring on oak exceed an inch in diameter and are filled, in the one case with a brown spongy mass, in the other with thread-like fibres radiating from the center in all directions to the outer wall.

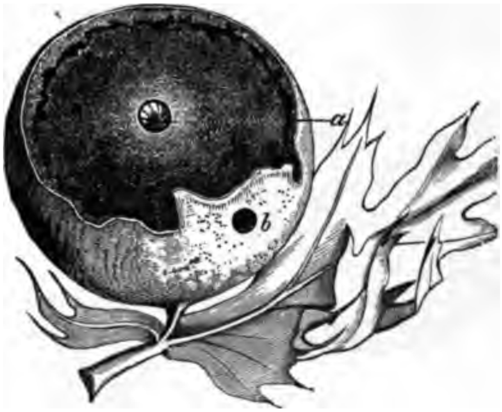


Figure 3.—A spongy oak gall: from Riley.

On the twigs and branches the galls may be also marble-like in appearance or they may be mere swellings or other protuberances. One of the largest and most common forms occurs as a potato-like swelling on the trunks and branches of young and twigs of older trees. It is fully 1¼ inches in diameter as a rule, and sometimes considerably more. Through the outer envelope comes, in due time, a series of pointed processes which are, each of them, larval cells: in other words, instead of the gall being produced by and containing only a single larva, some 50 to 100 have combined to form the larger swelling, in which each larva has a separate cell.

In some cases the very tips of the shoots become swollen and distorted, so that the gall is really a malformation of the shoot itself; or there may be a cluster of soft ovoid growths so close together as to press themselves out of shape and produce a series of irregular, more or less transversely flattened blisters.

More rarely galls occur on the roots, and these are usually irregular, lumpy swellings.

But not the Hymenoptera alone produce galls: quite a number of Diptera, or flies, belonging to the family *Cecidomyidæ* produce abnormal growths on leaves or twigs. One species attacks the base of the leaves of pines and causes an abnormal onion-like swelling at that point; quite a number are found making galls on the hackberry, while the willow is especially favored by them: all sorts of abnormal growths being produced, from little swellings to small cabbage-heads.

A few of the beetles are gall-makers—some on pine, like *Podapion gallicola*, others on deciduous trees—and these galls are usually mere swellings on the twigs or branches, in which the larvæ feed.

Phylloxera galls are common on hickories, and it is not an uncommon thing to see a young tree with the leaves covered with the large blister-like galls which are open inferiorly. If one of these galls be cut open, the inner surface will be found so crowded with the insects that they can scarcely find room to insert their beaks to obtain food.

Plant-lice, belonging to the same order as the *Phylloxera*, also produce more or less obvious gall-like growths, and the elm is a favorite tree for their attack. Sometimes there is a mere curling and distortion of the leaf, like that caused by *Schizoneura americana*, but often a real swelling, like the cocks-comb gall made by *Colopha ulmicola*, is produced.

It seems, thus, that most of the orders of insects outside of the Neuropterous series contain gall-makers, and all of them are, of course, some sort of draft upon the tree. The least drain, perhaps, is made by the gall wasps, or *Cynipidæ*, where the larvæ seem to feed chiefly upon a secretion in the central cell and not upon the gall tissue itself.

Plant-lice have been mentioned as gall-makers, but they occur also in great numbers, living freely upon the leaves or succulent growing shoots. No kind of tree is free from one or more species of these pests, and no sort of insect makes a more continuous drain upon the vitality of the attacked plant. Individually insignificant, their numbers make them dangerous, and their habit of excreting the plant juices in the form of "honey-dew" gives them the power of disposing of their food material more rapidly and in greater quantity than any other kind of insect. And they attack all parts of a tree: not only are they abundant among the foliage and branches, but even underground among the roots, and the latter are among the more serious forms. Of course, seasons affect the number of species and specimens of a species, to a very large extent. In wet seasons one set will become troublesome; in a dry season another will be in evidence while the former can scarcely maintain itself. And so of the trees: in some seasons plant-lice attack will be serious; in the ensuing, scarcely a trace of aphid injury may be found in the district.

Scale insects belong to the same general category as the plant lice in so far as they are suckers of the plant juices, but they are more dangerous because their attack is more continuous, because they are less exposed to adverse climatic conditions, and, perhaps, because some, at least, do exercise a really poisonous influence upon the plants. Soft scales are comparatively rare in the forest, and only the Tulip tree, *Liriodendron Tulipifera*, is seriously attacked in New Jersey. Of the armored scales the oyster-shell bark-louse, *Mytilaspis* species, is sometimes seriously destructive in the more northern sections on the walnut and butternut trees. Willow and poplar, which are also attacked, seem to stand the injury better. The nut trees are of comparatively slow growth, and when the twigs or smaller branches become thoroughly encrusted with scales, death is only a matter of time, usually a short time.

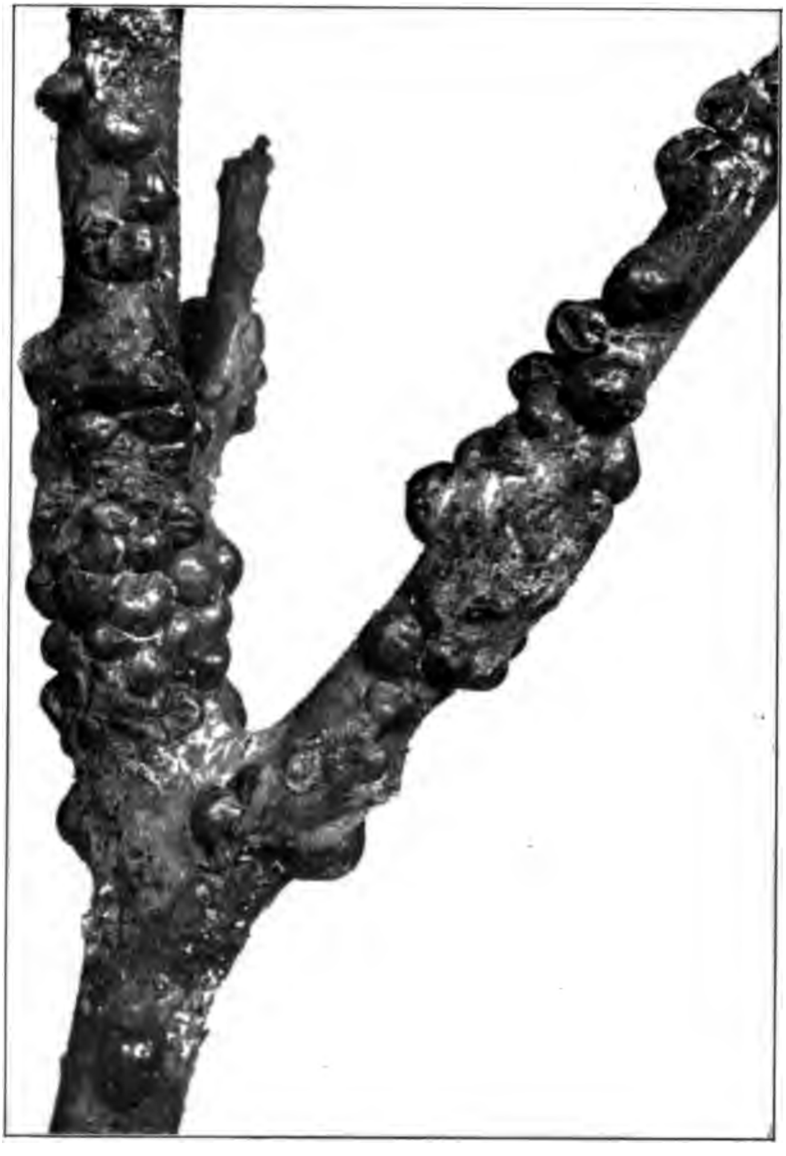


Plate No. XV.—The tulip soft scale, *Lecanium Tulipifera*.

enter healthy wood, in which, while they may not be able to breed, they may be able to set up a condition of affairs that will afford a proper home for a subsequent horde.

Meanwhile, further from the injury, but affected by it because of a lessening or interruption of the flow of sap, flat-headed borers have gained a foot-hold. They have begun to form shallow chambers in the sap wood, in which they live one, two or three years, constantly enlarging their field of operations and driving galleries that further interrupt the flow of sap until they are ready to pupate. Then they bore a short distance into the trunk, lie dormant in the pupal stage for a shorter or longer period and finally emerge as adults, ready to reproduce their kind, preferring the tree they themselves fed upon for purposes of oviposition, if it is at all suitable. As a result dozens of galleries replace the few, water gains further entrance here and there and cavities beneath the bark become obvious. These afford shelter to a large series of species that do not directly injure the tree, but by bringing in excrementitious matter favor the development of decay germs. Fermentation sets in, and a host of flies and sap beetles are on hand at once to further the disintegration of wood fibre. Finally a sheet of bark becomes loosened and falls; then come another lot of borers into the heart-wood: Scolytids or shot-hole borers, round-headed borers, boring caterpillars, goat-moths or Sessiids, and in some instances ants or Termites, though these usually come when the fate of the tree is finally sealed.

Of course, the progress of the insect attack is slow or rapid, in proportion to the extent of the original injury. If the injury was at all extensive, as a scorching of one side for several feet, two or three years will suffice to doom the tree and place it in control of the scavengers whose duty it is to reduce it to dust. If it was limited, several years may be required, assuming that the tree does not succeed in scarring over the original wound.

As the trunk becomes the object of primary attack when the injury starts there, the effect on the crown may not be immediately noticeable. But any serious interruption to the flow of sap is bound to have an effect on the area that should be supplied through the injured tract, and at once the insects mark the weakness. Twig borers enter at the tips and kill the young

Pine needles are attacked by a white scale, *Mytilaspis pinifolia*, that is responsible for disfiguring and considerably injuring trees in some parts of South Jersey.

There are, of course, numerous species other than have been mentioned; it is possible to indicate here only some of the principal types that may be commonly found feeding or living on the foliage and more actively growing portions of trees.

But the real enemies of the forest are not usually those that outwardly attack a healthy tree, though these do their share of harm; but the forms that lie in wait for the weakling, the maimed and the cripple, depriving them of the chance of recovery.

This is especially true in a State like New Jersey, where the forest areas frequently suffer from fires, large or small, from cattle, from careless cutting and from numerous other causes not found in primitive forest areas.

Send through a strip of woodland a fire that burns only the leaves and undergrowth, and does no more than scorch the trunk or kill an occasional branch, and watch the result. In a few weeks or months thereafter, according to the season, the undergrowth is renewed, and, superficially, the signs of injury have disappeared. Yet if we examine the trees themselves more carefully, we read another tale: wherever the bark has been scorched and killed, wherever a branch has been burnt, wherever twigs have been charred or deprived of life, and, in short, wherever a wound of any kind has been made, there we find that borers have entered. Little piles of sawdust at the base of the tree attract our attention, and if we trace them to their source we find little round holes, the size of a pin-head or thereabouts. These go through the bark and either into the solid wood or into the bast or sap-wood.

The culprits are "shot-hole borers," "bark-beetles," or Scolytids—little cylindrical beetles varying from less than one-sixteenth to an eighth of an inch in diameter and from one-sixteenth to three-sixteenths of an inch in length. Their work below the bark and into the wood gives entrance to moisture and germs of decay that weaken a larger area, in which the next brood finds a congenial home; and, coming out in numbers that cannot all find entirely suitable areas, they attack and enter healthy wood, in which, while they may not be able to breed, they may be able to set up a condition of affairs that will afford a proper home for a subsequent horde.

Meanwhile, further from the injury, but affected by it because of a lessening or interruption of the flow of sap, flat-headed borers have gained a foot-hold. They have begun to form shallow chambers in the sap wood, in which they live one, two or three years, constantly enlarging their field of operations and driving galleries that further interrupt the flow of sap until they are ready to pupate. Then they bore a short distance into the trunk, lie dormant in the pupal stage for a shorter or longer period and finally emerge as adults, ready to reproduce their kind, preferring the tree they themselves fed upon for purposes of oviposition, if it is at all suitable. As a result dozens of galleries replace the few, water gains further entrance here and there and cavities beneath the bark become obvious. These afford shelter to a large series of species that do not directly injure the tree, but by bringing in excrementitious matter favor the development of decay germs. Fermentation sets in, and a host of flies and sap beetles are on hand at once to further the disintegration of wood fibre. Finally a sheet of bark becomes loosened and falls; then come another lot of borers into the heart-wood: Scolytids or shot-hole borers, round-headed borers, boring caterpillars, goat-moths or Sessiids, and in some instances ants or Termites, though these usually come when the fate of the tree is finally sealed.

Of course, the progress of the insect attack is slow or rapid, in proportion to the extent of the original injury. If the injury was at all extensive, as a scorching of one side for several feet, two or three years will suffice to doom the tree and place it in control of the scavengers whose duty it is to reduce it to dust. If it was limited, several years may be required, assuming that the tree does not succeed in scarring over the original wound.

As the trunk becomes the object of primary attack when the injury starts there, the effect on the crown may not be immediately noticeable. But any serious interruption to the flow of sap is bound to have an effect on the area that should be supplied through the injured tract, and at once the insects mark the weakness. Twig borers enter at the tips and kill the young shoots, or they may bore in at the base of the new growth, causing it to wilt; girdlers find the branches attractive, and a great variety of creatures, chiefly beetles and flies, with a few Hymenopterous species, perhaps, continue the attack from above.

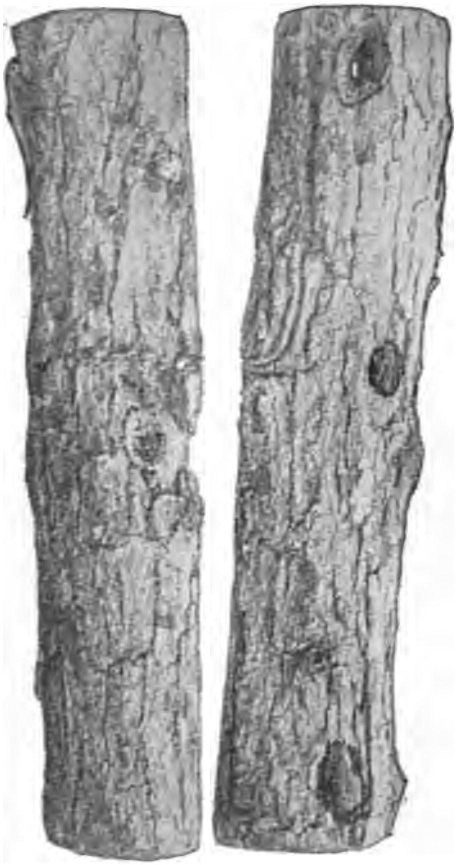


Figure 4.—A stick of oak, 4 inches in diameter, showing woodpecker holes made to get at a borer inside

Now comes another factor—the woodpecker and its allies, that make war upon the borers. They peck and hammer away at infested spots, and many a fat borer falls prey to their activity and industry, but wherever they haul out a specimen they leave a hole, and that is, too often, an entrance point for the water, that, after all, is as much to be dreaded in the tree as it is useful when it reaches the roots through the soil.

Thousands of oaks in South Jersey, four to eight inches in diameter, are "doated" and useless except for short posts or firewood because of the well-meant efforts of woodpeckers to clear the tree of borers.

In this case the boring insect is the larva of the "goat moth," *Prionoxystus robiniæ*, and this makes a gallery about three-sixteenths of an inch in diameter as nearly as possible in the center of the trunk. Our woodpecker locates this larva with great exactness and drills a hole two to four inches deep, about one and a-half inches square at the surface, and tapering to the diameter of the burrow. In most cases he gets his larva at the

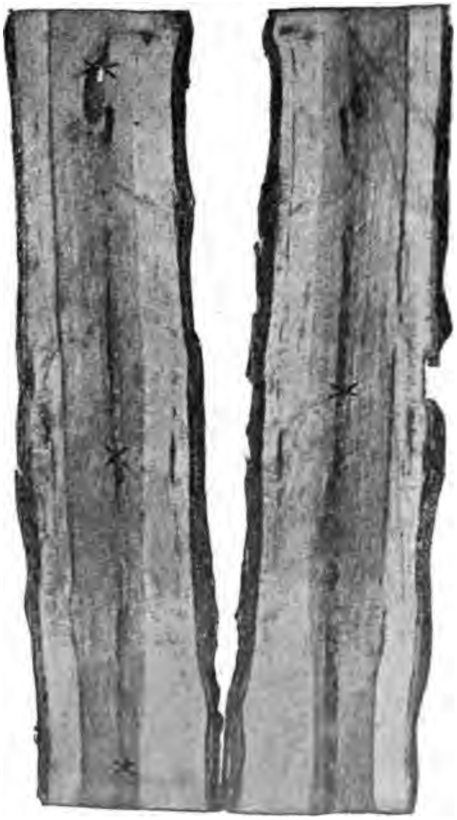


Figure 5.—The same stick as Figure 4, cut through to show the burrow made by larva. The X marks indicate where the woodpecker hit the burrow, in each instance needing two holes to get a larva.

first effort; but failure is not infrequent, and as many as four such holes may be drilled into a small tree from different sides before the grub is finally landed. A tree so treated is spoiled for all purposes save the wood-pile. It may recover, yet it will never completely outgrow the injury done—not by the larva, but by the bird.

The "goat moth," by the by, deserves more than a mere passing notice, because of the real injury done, not so much to the tree, as such, as to the timber that it should make. The insect derives its popular name from its peculiarly pungent and unpleasant odor, which is most intense in the pupal stage, and is, perhaps, protective. The moths are large, expanding from two to four inches, the wings more parchment-like in appearance than usual in this order, and the body in form somewhat like the hawk moths. They do not feed, fly chiefly at dusk or in the night, and are rarely seen even when the larvæ are abundant. Eggs are laid in some wound, preferably the very spot where a moth has already emerged, and the young caterpillars start from that point. A tree once infested, therefore, is likely to remain so, and at the point of entrance quite a decided swelling usually forms, in which is a more or less obvious scarred opening. The caterpillars are white or with a pinkish tinge, just a little flattened, with rather prominent black warts or tubercles, each of which bear stiff, bristly hairs. The head is large, brown, and with prominent jaws. When full-grown they are fully two inches in length, and early in the third year the pupa is formed in the gallery, near the surface, and preferably at just about the point where the entrance was effected. The borer is no great feeder, considering its size and length of life; its burrow rarely exceeding six or eight inches in length, of equal diameter throughout, so that the larva may move from one part to the other at all times. A young borer entering one of these old burrows may continue it upwardly, or may start a lateral from it, curving upward soon after he gets well away from the old one, and so a series of galleries may start from the one point of entrance, each year adding a little to the sum of injury and detracting as much from the value of the timber. Since they do not really interfere with the nourishment of the tree, they are not likely at any time to cause its death, and I have seen examples where all external wounds were healed over years since, yet whose history of prior infestation was plainly to be read when the trunk was split, the old burrows found and the gnarled and twisted tissue of the old entrance laid bare. These defects are never repaired, and a burrow once made in the heart-wood of oak is there for all time.

Trees of this kind should be selected for firewood or for such purposes as they are suitable, and the sections containing the larvæ should be used not later than June 1st, to prevent the emergence of the moths. The cutting should be done, of course, in winter.

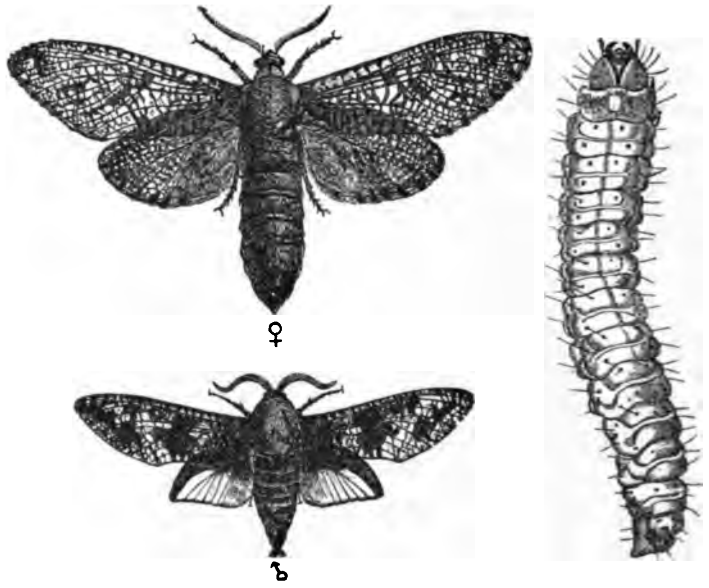


Figure 6.—Goat moths: female above, male below, and larva: from Riley.

Scrub land is peculiarly subject to insect injury when even a small fire has been through it. There are hundreds of acres of oak brush in South Jersey, and each year some portions are more or less scorched. The season following, almost every one of the shoots or saplings will be infested by round-headed borers of the genus *Elaphidion*, commonly known as "oak-pruners." Their normal habit is to bore into oak twigs or branches until they are full-grown, then to cut the twig from the inside until it is held by a mere film of bark that will break in the first high wind, carrying the borer to the ground in a shelter that remains unchanged during the remainder of its larval and pupal life. In the injured oak-shoots the larvæ find ideal conditions for their development, and they seem to realize that here there is no necessity for girdling, because they make not the least attempt in that direction. These borers remain in the trees one year only, and after that the wood is no longer in the right condition for them; they leave it for others that delight in dead wood, and of these there is no lack. There is another consequence, however: where so many beetles develop they are hard put to it to find a place to breed, therefore they attack many trees that would, under ordinary circumstances, escape. Hence apple trees are frequently attacked and sometimes seriously injured, and large shade trees in parks and gardens are subjected to a merciless pruning.

I think I have indicated sufficiently that the natural tendency under normal forest condition is to eliminate the weakling and the cripple, and that insects are among the chief agencies by means of which this is accomplished. The hosts of species that feed upon or in the foliage are comparatively of little importance unless they strip the trees. This sometimes happens, and then the proper conditions may be induced that result in a successful borer attack.

These borers are of three kinds, the bark or shot-hole borers, Scolytids; the flat and the round-headed borers, Buprestids and Cerambycids respectively; all of which have been already mentioned.

The Scolytids are generally divisible into those that make galleries under the bark and those that work in the solid wood. The work of the former is most obvious, and their galleries, radiating from a single central channel, are obvious when a flake of bark is removed. Their method of causing injury is equally obvious; boring as they do between bark and wood, and partly in each, they interrupt the flow of sap, and when many of them are present, in effect, girdle the tree. These borers rarely attack healthy trees; but it does not need much to give them a foothold. Trees in parks, without proper supply of nourishment or in sod, on land too well drained, are often attacked and killed when to all appearance they are sound as a dollar; and this may be so, too, where woodland has been too thoroughly opened up or where natural water-courses have been diverted and the usual supply of moisture has been either decreased or added to abnormally. When once these beetles have secured a good foothold the tree is doomed, and good forestry practice is to take it out and use it up immediately.

Almost every species of bark-beetle makes a gallery peculiar to it, so that to one familiar with their habits a look at their work tells the species even if no adult insect is available for examination. Yet there are certain features that most of them have in common; usually the female parent bores into a proper tree, through the bark to the sap wood, and in the layer between bark and trunk, though mostly in the bark, a vertical channel or burrow is made. A series of small chambers are nicked out at each side of this channel and in each of them an egg is laid. The larva, when hatched, at once starts a channel or burrow of its own, narrow and thread-like at first, but becoming larger as the grubs increase in size and each channel diverging from all the others so that they rarely cross. The pupa is formed at the end of this larval gallery in a little cell eaten out for that purpose, and the adults come out through little round holes bored by them when fully matured.

In some cases the central gallery is even throughout; sometimes there is an enlargement or an oblique spur at one or both ends, or a chamber somewhere in its course in which the parent can turn around if it so desires.

Of this type is the Hickory bark-beetle that at Glen Ridge, New Jersey, killed off so many trees a few years ago. (See Figure 4.)

The Scolytids boring in the solid wood are usually called shot-hole borers, because of the size of the hole and because the edges are generally blackened as by fire. The work of these beetles is not so obvious, nor is their ill effect so immediately visible as in the case of the previous type, yet they are always ready to do their share when the proper conditions arrive.

The typical shot-hole borers differ altogether in many respects from the bark-boring type. Their galleries go variable distances in the solid wood, then laterals no larger or longer than the beetle itself are driven, and in these the larvæ develop. They do not lay so many eggs as the bark borers, but multiply rapidly

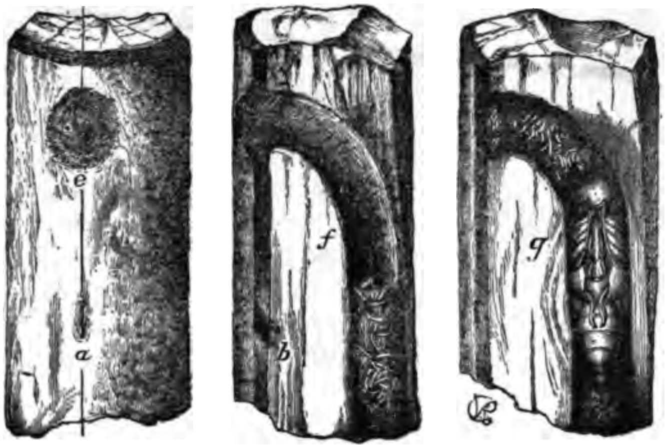


Figure 7.—Round-headed apple borer: *a*, puncture in which egg is laid; *b*, same in section; *e*, hole from which beetle has emerged; *f*, same in section; *g*, pupa in place.
From Div. Ent., U. S. Dept. Agl.

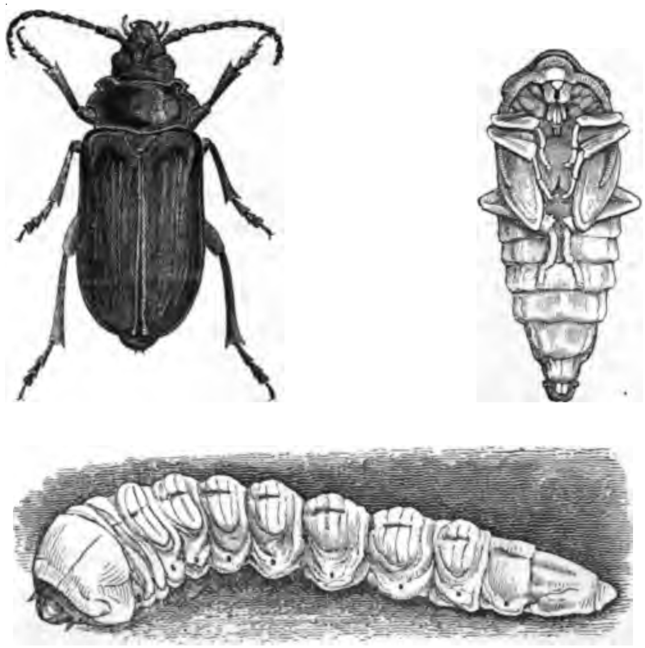


Figure 8.—Giant borers, *Prionus* species; larva, pupa and adult natural size From Riley.

enough for practical purposes. A very striking character in some species is that, while they really bore into the wood, yet the larvæ have to be fed by a peculiar fungous growth known as *Ambrosia*. All the real boring is done by the adults, and the galleries once seeded down to *Ambrosia* are inhabited by successive broods of species, the dark staining in the wood resulting as much from the fungus as from the work of the beetles. On small trees a number of these beetles working at or near the same place may so weaken the trunk that it will break in the first high wind that comes along.

Other species seem to prefer the very center of twigs, boring out the minute core in oaks and using the galleries thus made as a winter shelter.

The round-headed borers are more or less cylindrical, white or yellowish grubs, the segments usually very well marked, and the "head," or anterior portion, considerably enlarged or swollen. These forms frequently attack living wood, and bore, usually, in the solid tissue, though some may burrow, for a time at least, beneath the bark or in the bast. To this series belong the "oak pruners," the "twig girdlers," the "bark slippers" (concerning which more will be said hereafter), the "giant root-borers," and a variety of other pests. The adults are Longicorns, or long-horned beetles, and all are feeders in woody or stem tissue in the larval stage. As adults they are not injurious, and are apt to be found on flowers, though some species are distinctly rare even when their larvæ are not uncommon. Thus oak sprouts are attacked at the base by a borer which kills a large percentage of them each year, and this borer is not at all rare; but the beetle, *Goes tessellatus*, may be sought for years before even a single example will be captured.

As an example of the injury done by these longicorn borers, that attacking the locust may be cited. There is scarcely a locality in the State where these trees are not rendered utterly worthless by the attacks of these insects, and, while the trees may live under the attack for years, they are never good for anything. And this leads me to call attention to another point: the longicorn borers are mostly wood feeders, and when they attack healthy trees, as many of them do, they bore at once into the trunk or the body of the branch. If they work in the bast or sap-wood at all, it is for a short time only in the early stages of growth. The tree derives its chief supply of nourishment through this bast and sap-wood, which is scarcely at all injured by these larvæ, hence they may work for many years without causing fatal results, if they are alone in their attacks. The Scolytid borers working the sap-wood or bast interfere at once with the nourishment of the tree, and the results are immediately noticeable. The result of this difference from a practical standpoint is that a tree killed by Scolytids may make fair timber; one that has been long infested by longicorn borers will be worth little or nothing, though the insects may not have killed the tree. The function of other of these borers attacking dead or dying wood will be again referred to.

Flat-headed borers resemble the round-headed forms in general shape, but are compressed and flattened, the "head" segments comparatively broader and the body somewhat longer, so that they have been called "hammer heads." These borers in the main attack weak, sickly or dead trees, though one group, the Agrilids, forms an important exception. They live chiefly just under the bark or in the sap-wood, forming irregular shallow chambers connected by short, irregular galleries. Some of them live two or three years in the larval stage, and, before transforming, bore a short distance into the wood to form a pupal chamber, issuing later through a hole in the bark, as do the longicorns. It is easy to determine at all times whether a tree has been infested by round or flat-headed borers, for in the first instance the exit hole is as round as if it had been bored by an auger, while in the latter it is regularly oval. The flat-headed borers come with or after the Scolytids, rarely before, and when the two are together present the flat-headed grubs often extend their chambers throughout an entire gallery system of a bark beetle, destroying everything in their way.

The adults of these borers are *Buprestids*, for whom there is no satisfactory common name. They are long and narrow, somewhat flattened, tapering posteriorly, very hard in texture and generally metallic in color. Some of them are bright green, or brilliantly copper gilt, but most of them are more soberly bronzed or have a metallic green or blue reflection.

The species of *Agrilus* are the smallest of the series, rarely more than one-quarter of an inch long, very slender and always bronzed. Their larvæ are similar to those already described, but attack healthy plants, and, instead of excavating chambers, make long winding burrows, often completely girdling small branches and causing injury altogether out of proportion to their size. This reference to size also brings to mind the further fact that the larva in this case is excessively large in proportion to the size of the adult, an inch and a-half borer making a one-quarter-inch beetle. They are called sinuate borers, from the character of their burrows, and chestnuts are frequent victims, some forms also attacking orchard and small fruits.

Besides the Coleopterous borers just described, there are several boring caterpillars that may be always distinguished by having eight pairs of more or less developed legs. They bore in the solid wood as a rule, and rarely in sufficient numbers to cause actual injury. Their chief danger lies in the fact that they open the way for the other species that endanger the tree itself.

The goat moth, coming of the largest of these caterpillars, has been already mentioned. The others belong chiefly to the clear-winged moths of the family *Sesiidæ*. The caterpillars are more cylindrical than those of the larger species, and the head is usually black; otherwise they are very similar. The pupa is quite generally provided with a more or less developed chisel-like process to the head, by means of which it cuts its way through the bark. It wriggles through the opening so made until it projects half its length beyond the tree, being held in place by the rings of spinules and pointed processes with which the segments are set. The moths are usually black, marked with yellow, more or less resembling a wasp or hornet, and the wings are also narrow and transparent, to heighten the illusion. These borers are in many of the forest trees and occur in all parts—quite as often in the roots as elsewhere. In some cases city shade trees become the victims and the maple is particularly susceptible to attack.

Heretofore I have spoken of the species that attack the healthy, sickly or injured tree to cause its death, and this is one important way in which injury is caused to forests. Another kind of injury comes in when for any reason timber is killed purposely or dies standing, before being made into lumber. A dead tree is a carcass to be removed, and dozens of species and thousands of specimens begin work at once, the borers of course doing the main work at the beginning and opening the way for decay and the species that further it. Species of all sizes will bore little holes, most of which blacken or discolor, and lessen the value of the boards into which the trunk may be cut. Then the larger galleries prevent its use for that purpose altogether. After the larger borers have made a good start, ants come in and occupy their galleries, extending and connecting them for their own guests and other messmates, which, though they do not directly feed upon the wood, yet open up new points for decay. Termites, or so-called white ants, come along and work at the surface or underground, and these are destructive when once started. They are typical wood-feeders, and their colonies contain countless numbers, reducing a tree to a mass of galleries in an astonishingly short time. When once these insects have made a fair start in a trunk, its value as timber is gone. In fact, it may be said that from the time life has ceased, standing timber deteriorates continually and ever more rapidly, primarily as the result of insect-attack.

If a load of cord-wood be cut in winter and piled, it makes an excellent collecting-ground the year following. From the time that spring is fairly open, beetles, flies, many Hymenoptera and some visitors of other orders flit about it, some seeking food or shelter merely, others a suitable point for breeding. In mid-June it will be a busy scene during the warm sunny hours, and all seasons new forms keep coming. During the latter part of the winter following it will be noted that much of the bark on the sticks comes off easily, and in the following spring it can be lifted off readily from the majority of them. Examination will show that the tissue between bark and wood has been completely eaten out by a series of larvæ which are called by the woodmen in some localities "bark-slippers." They are round and flat-headed borers, though the former predominate, and are mostly members of the genus *Phymatodes*, all of whose species have similar habits. Beneath this loose bark we find secondary species: members of the order *Thysanura*, spring-tails mostly, that occur wherever there is moist, decaying or fermenting vegetation of any kind. With these, and probably preying upon them, are the little pseudo-scorpions, or Chelifera, which may be found in all stages in early summer. Centipedes and millipedes, the predatory and vegetarian types, find here both shelter and food, while sow-bugs (*Oniscus*) are found in the lower tiers.

The bark slippers, when they have attained their full size, eat a short distance into the wood to form a pupal chamber, whose entrance they plug up with shavings until they have reached the adult stage. Where tan-bark is made, these same species sometimes do considerable mischief, boring in the bark itself or between the layers, lessening its value and occasionally ruining it where left out-doors too long.

No wood can be too hard, too dry or too dead to secure it against borer attack, though its condition may often retard their development. Larvæ that live in concealment and grow slowly, requiring two or three years to reach a stage which other insects attain in as many months, may, under favorable conditions, have their development greatly retarded. Logs may be cut up into boards, made into furniture, and come into daily use without harming the contained borers, some of which have lived for more than a decade under such conditions.

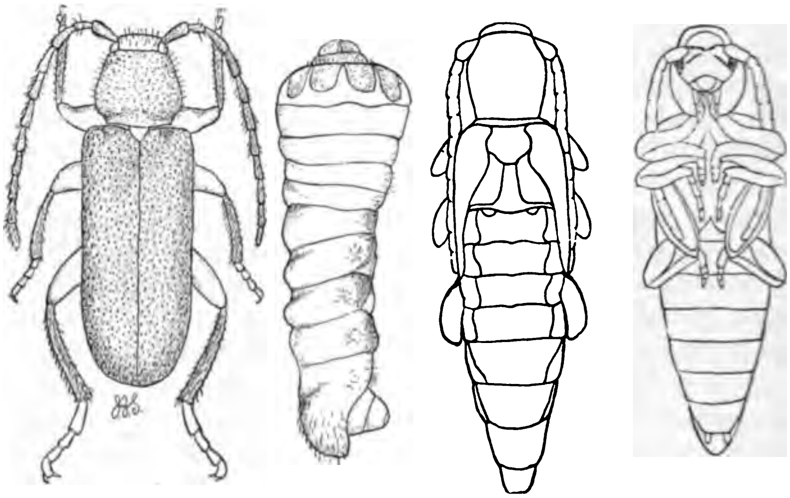


Figure 9.—A "bark slipper," *Phymatodes* sp., in all stages—larva, pupa above and below, and adult.

In March, 1898, the yellow-pine wainscoting of a building in Somerville was found to be filled with round-headed borers. It had been in place five years, and, when discovered, the insects had bored out almost the entire center of each board, leaving only a mere shell. Of course the whole work had to be removed, and I secured some specimens, intending to raise the species to maturity; but, in October, 1899, the larvæ are yet unchanged and manifest no apparent desire to get into the pupal stage. This case demonstrates both the longevity of the insects and the damage caused by them.

A somewhat different case occurred in Jersey City, where hardwood timber had been made into paneling. The wood seemed in fair condition; part of it was veneered and all of it was filled, heavily varnished and polished. In the spring of 1898 the owner was astonished to find the little powder post beetle, *Lyctus striatus*, emerging in great numbers, leaving their small exit holes everywhere in such quantity as to utterly ruin the appearance of his trimming. The larvæ, in their early stages, had not been noticed when the material was worked up, and had developed normally after the woodwork was finally in place. It is difficult to cover wood so as to prevent beetles from *coming out*, but as a rule the insects need a recognizable surface for entrance and will rarely *enter* a varnished or painted board or post. Indeed, even lime will answer as an outdoor preservative, very few insects caring to bite into or even to come to rest on it. The latter, however, may be due to the fact that they are too conspicuous on such a white surface for their own safety.

A fallen tree or log left to lie in the forest first becomes a prey to bark slippers, as in the case of the cord-wood; but the bark remains in place and furnishes shelter to the host that is working beneath it. Click-beetles, and their larvæ, the wood-feeding wire-worms, come in, as do also the grubs of some of the weevils. These make surface burrows only, but in the heart-wood are the giant borers, both round and flat head, that make galleries nearly one-quarter of an inch in diameter. These attain a length of from 2 to 3 inches, and the resulting adults are the largest of their kind. The round-headed borer makes a species of *Prionus*, a stout black, long-horned beetle about 1½ inches long and half an inch in width across the shoulders. It is one of the species of slow growth and requires three years to come to maturity. Examples are most frequent in pine logs, living in the "fat," which without their assistance would resist decay indefinitely.

The wire-worms do not, as a rule, enter a tree or log until germs of decay are present, and they are not borers in the real sense of the word, except in soft or dry rot. The smaller species as a rule remain close under the bark and do not get into the body of the tree at all; but the larger species may be found wherever the tissue is soft enough to be penetrated by them.

The largest of all is about 1½ inches long and produces what is known as the eyed Elater, *Alaus oculatus*. It is over an inch long, loose jointed, gray and black speckled, the thorax with two very large eye-like black spots, one on each side, which attract attention whenever the insect is seen and make it easily recognizable.

The hammer-heads make a species of *Chalcophora* about an inch in length, not over one-fourth of an inch broad at the shoulders, tapering posteriorly, somewhat flattened above and more or less bronzed in color. These borers are not so long lived as the longicorn larvæ, and I know of no instance of their remaining in the larval state so many years under adverse conditions.

When water enters and decay has actually begun, another series of larvæ comes in—the "white grubs." White grubs are cylindrical, fat creatures, almost always curled up in a ring, with yellow or brown head, large, powerful jaws or mandibles, six well-developed brown legs and a very blunt posterior extremity. The creatures are clumsy in appearance and helpless when taken out of their burrows, their small fore body being incapable of properly supporting and balancing the clumsy, food-distended hind body. From the largest of these white grubs, distinguished by its ivory-like color and texture, comes our stag beetle, *Lucanus dama*, also known as the "pinching bug," because of the prominent mandibles of the male.

Gnawing at the roots of the stumps are others of these large grubs, from which come the "Rhinoceros beetles," so called because of the long horn on the front of the head, and others without a common name, species of *Strategus*, with horn-like processes on the thorax—formidable creatures all of them, in appearance, but actually harmless. It is not often that these insects are seen by the uninitiated, but they are, nevertheless, present, and are sometimes quite numerous in the Pines.

Exactly how much harm they do is perhaps a question. Their life history is not well known, and just how much living tissue the larva requires to bring it to the pupal stage is yet to be ascertained. It is reasonably certain, however, that they require two or more years to reach maturity, and that their presence alone does not indicate any serious danger to the trees.

There are other of these large grubs, feeding in decaying stumps, like the species of *Osmoderma*, black or brown in color, broad and a little flattened, with a peculiar, somewhat leathery odor, only a feeble indication of the intensely disagreeable effluvia of the giant *Dynastes* of the more southern States, which appears in New Jersey only as a very occasional visitor.

Smaller white grubs are nibbling away at the edges, so to speak, near the exposed ends of the log or trunk, leaving a little dry crust between themselves and the outer air. These are species of *Valgus* and allies, which, though they be common enough, are rarely seen except by the entomologist. When decay has proceeded well along, and the log has become unfit for most other species, the larva of *Passalus* comes along and does the finishing work.

This is also a white grub, grows to be almost two inches long, and differs from the others by having four legs only. The beetle is oblong, black, an inch and a quarter or more in length, somewhat flattened and with a little curved horn on the head, whence it derives its specific name, *cornutus*. When this insect gets through with a log or stump, it can be kicked to pieces without much effort, and of real wood fibre little is left beside the shell.

Stumps are in the same category with fallen trees and logs, the same general types of insects attacking them and causing their reduction to dust. Stumps, however, are more likely to be invaded by Termites, and when these take possession nothing else will be found. Ants, particularly the black and brown carpenter ants, are found in logs before they are much advanced in decay.

In this superficial sketch only the more prominent types of insects concerned in forest injury or in reducing a dead tree to vegetable mould have been mentioned, those forms chiefly that any one with a little ability in observing can find without much trouble. The numerous types of Rove beetles, sap beetles, fungus beetles, &c., that are always found on dead and dying wood have not been even mentioned.

A fallen tree in the second season on the ground will occupy an entomologist an entire day in its exploration, and insects in some stage will be found in all parts of it; and each year brings different forms, adapted to live under the changed conditions until, when the woody mass can be crumbled between the fingers, the minute little *Scydmœnids* and *Pselaphids* are sifted out over a cloth.

There is another set of insects that may have the effect of crippling or distorting a tree, as, for instance, the white pine weevil. This attacks the leading shoots of pine, fir and spruce, the larva boring into them and forming large cavities. When, as is usually the case, a number of the grubs are found in one shoot, it withers up and dies, leaving the plant to send out a new leader from another point. That, of course, destroys the symmetry of the tree, and a cripple results, of no value for ornamental purposes in a park and of little use for timber, should that stage be ever reached, for, once the victim of an attack of this kind, the tree seems predisposed to further injury of the same character, so that several leaders may be killed and the tree transformed into a mass of forks.

Another weevil larva attacks willow in much the same way, save that the infestation is more general, no "leading" shoots occurring in this tree. In fact, quite a number of weevil larvæ bore into twigs or branches or live beneath bark, causing local trouble, rather than general effect on the plant attacked.

The larvæ of weevils are somewhat like white grubs in shape, but much smaller, not so much curved, without the peculiarly rounded anal segment and without legs. The grubs found in chestnuts, hickory nuts and acorns belong to this tribe, and give a good idea of the general appearance of curculio larvæ.

It cannot be insisted too strongly that there is an insect host constantly on the watch to reduce to dust every tree that shows the least trace of flagging vitality, just as there is always ready a group of seedlings ready to take part in the struggle for the place vacated by a dead tree. It is indeed a continuous battle, not only between plant and plant, but between plant and insect, and, in the long run, under normal conditions, both thrive. Both have their hard times and seasons of distress, and when one is up the other is down; but both maintain themselves. The object of the forester is to give his trees a little the advantage, to enable even the one low in vitality to make good its position, and to keep the wood product at the best and highest market value. To go into details is obviously impossible here, but some few suggestions can be given that will be useful where any attention at all is paid to woodland.

The first and most important feature is what corresponds to clean culture in the orchard and field; *i. e.*, the removal of all undergrowth and other material that would in any way interfere with the growth of the trees. This is often a matter of considerable importance where the soil is poor and the trees need all the advantage that they can get in the way of securing nourishment. It gives a better, healthier growth, offering no encouragement to insect attack, while the removal of the undergrowth deprives many forms of a shelter from which they await their chance to get at the trees.

It has a further direct advantage in that it removes altogether certain forms that attack the forest trees in one stage only. Thus a species of Ptinid beetle lives in the larval state in the roots of green or cat brier or in dead grape, the adults boring into the twigs of trees to obtain food and for shelter. The destruction of these briers removes one source of injury.

Freedom from undergrowth will facilitate other operations, in case of any unusual insect attack on the foliage. Complete defoliation by insects should be prevented at any reasonable cost, and it is rarely indeed that in our latitude this is threatened. Complete defoliation at any time means almost certain death to conifers; deciduous trees are not much injured by it, provided the terminal buds are not destroyed. They may be somewhat checked in growth and may in case of a drought ripen up prematurely, and have but a weakly growth the year following; but under ordinary circumstances, if defoliation takes place before midsummer, a new crop of leaves is produced in a short time.

Under the same general head of clean culture comes also the removal of dead and dying trees, and this is another very important measure. It has been already shown how great an attraction is a dying tree to boring insects, hence, as soon as it is discovered that a tree has become thoroughly infested, that tree should be at once cut out, removed and used up in some way, or if it cannot be at once used the bark should be stripped so as to expose the wood to the weather. This method will kill all insects which do not flourish in dry wood, and will, of course, prevent further breeding. The importance of this is not in the mere destruction of the insects in the one tree, but in the prevention of attack on the others. If a tree so infested be allowed to mature the larvæ in it, the resulting adults are apt to try other trees not naturally ready for them.

So a tree killed by girdling, by fire or in any other way, should be cut out as soon as may be to save the lumber in the best condition; the longer it stands the more holes there will be, and, of course, the less it will be in value.

Cord-wood made from live trees, in winter, should not be allowed to remain in the wood during the following summer, because in it so many insects will breed that may, when pressed, attack standing timber. In fact, the rule should be, broadly, to allow no dead or dying wood to stand or lie anywhere about, and the cleaning-up is best done in the early part of July, when the bulk of the wood borers are in the young larval stage.

It is good practice, also, to girdle a poor tree now and then, to attract what insects there may be about, serving thus as a trap and a protection to the other trees. This girdling should be done in winter for one set of insects, and in spring, after the trees are in full leaf, for another. Two trees thus treated will protect a considerable area of forest, and they should be cut out and destroyed the winter following.

Where a fire has been through any part of the wood, every tree, no matter how large or how small, that has been at all scorched, should be cut out. Such trees are almost certain to attract borers, and there is no greater ally or provider of insect food than this same fire. No shoot is so small that it cannot nourish some species, and to the entomologist and collector there is no richer ground for variety of species or number of specimens than a field of sprout-land through which a fire has run the year before. Hence such land should always be completely cleared for the protection of parts yet uninjured.

In general, birds are the foresters' friends, and should be encouraged; but I am not so sure about the woodpeckers. If there be no dead or dying trees no woodpeckers are needed to destroy larvæ, and on the other hand there is little likelihood that any will remain about where no chance for food-supply exists.

Frogs, toads, lizards and snakes are great entomologists, and destroy vast quantities of insects without in turn causing injury. Lizards, especially, destroy large numbers of wood-feeders, and should be encouraged.

Sometimes high winds, lightning or other causes injure or kill a branch or break it without harming the main tree, but leaving perhaps a ragged stump in case of breakage. All dead wood of this kind should be cut out, and all ragged stumps due to breakage should be properly trimmed off.

Direct insecticide applications are rarely practical in forest work, though in parks, where the trees have an ornamental value, they may become desirable. Against borers no applications can be made. The preventive measures already mentioned will suffice for them. The pruners or girdlers may be checked by systematically gathering and burning all the fallen branches in winter. This is really necessary on park land only, for the pruning done in the forest under normal conditions amounts to nothing, and natural enemies prevent too great an increase in the species. Isolated trees scattered in open groves are much more severely injured, and in such cases the gathering and burning of the pruned branches is indicated.

Where leaf feeders really endanger the tree or its foliage, particularly conifers, arsenate of lead will prove the best insecticide for general use, because of its harmlessness to foliage of all kinds.

Arsenate of lead is made by dissolving in water, in separate vessels, 4 ounces arsenate of soda and 11 ounces acetate of lead. The amount of water is immaterial, so it is sufficient to completely dissolve the chemicals. When the solutions are complete, combine the two and add water to make 80 gallons. This will kill most leaf-feeders in their early stages; but if the larvæ are well grown, or if adult beetles are to be dealt with, 40 gallons will be enough to use.

As to spraying machinery, pumps, nozzles, &c., that branch of the subject will be found treated in the reports and bulletins of the Agricultural College Experiment Station.

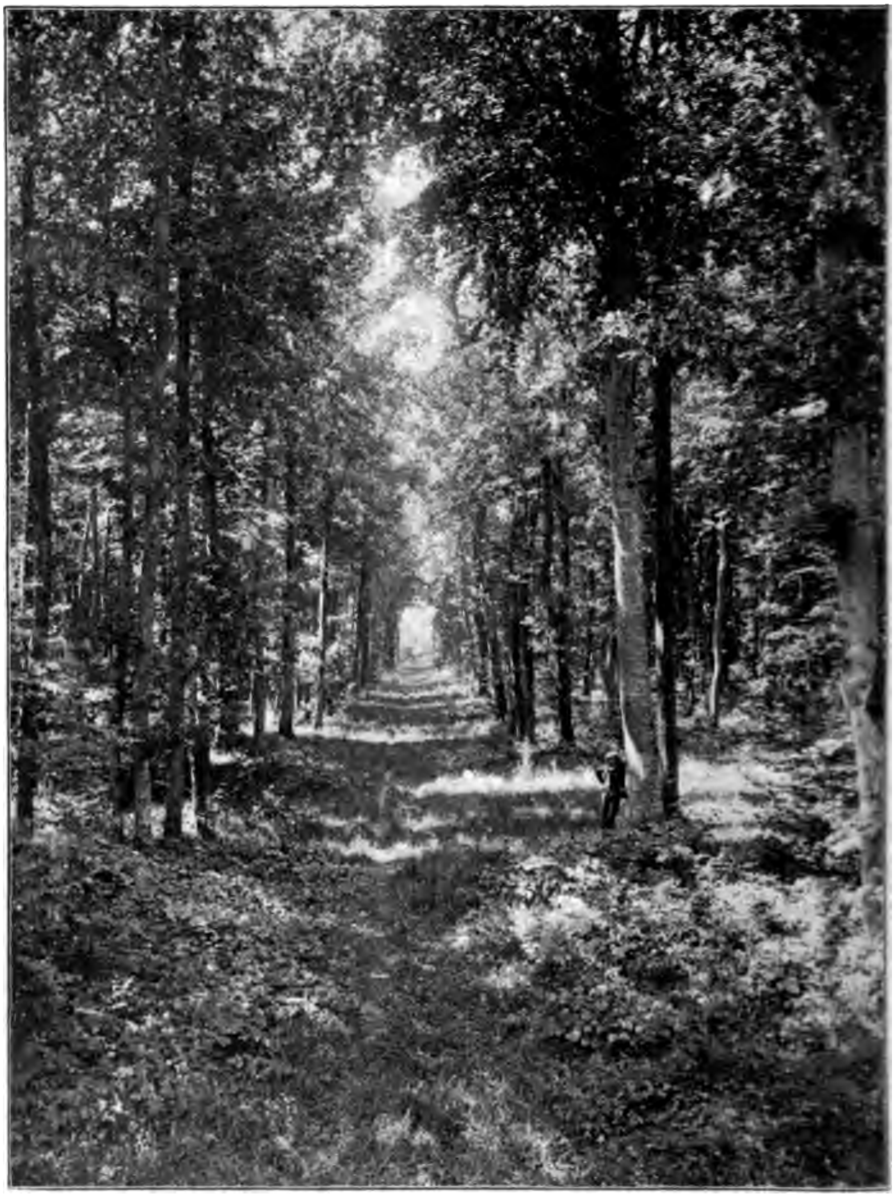
A very important method in European forest culture is banding with "Raupenleim" or similar sticky mixture impassible to caterpillars. This is employed chiefly against the larvæ of the Gypsy moth and the brown-tail moth, both of which now occur in the United States, but have not yet been found in New Jersey. At the present time there is no species against which such a method could be profitably employed in our forests, and it, as well as the allied method of trapping under cloth bands, requires more or less continuous attention. On a limited area of a park-like character burlap bands, such as are in use by the Massachusetts Gypsy Moth Committee, may prove useful as traps to many kinds of leaf-feeding forms that resort to it for concealment or for the purpose of pupation.

Such bands to be of any practical use must be examined at least once a week for the purpose of destroying what insects may be hidden there; hence their use presupposes a tract sufficiently valuable to justify the employment of some person sufficiently intelligent to exercise some discrimination in killing.

Finally, it may not be amiss to say that not one-fourth the damage actually caused by insects in our New Jersey forests could occur did not fires, great or small, first pave the way.

GEOLOGICAL SURVEY OF NEW JERSEY
REPORT ON FORESTRY

Plate No. XVII.



ENTRANCE TO THE PHEASANTRY OF COMPEIGNE, FRANCE

PART IV.

The Forestal Conditions and Silvicultural Prospects of the Coastal Plain of New Jersey,

WITH

Remarks in Reference to Other Regions and Kindred Subjects.

By JOHN GIFFORD, D. Œc.

Forestal Conditions and Silvicultural Prospects of the Coastal Plain.

I. General Description.

Although small in area, the State of New Jersey is very varied in nature.[*] In the north there are rough, wooded mountainous regions; in the central portions rich farm lands, and in the south vast stretches of sandy pine-lands. The average value of improved land in New Jersey is higher than that of any other State in the Union. The State is without a rival in reference to location and transportation facilities. If forestry cannot be practised with profit in this region, there is little hope for it elsewhere in eastern America.

The region to which this title refers is located in the southeastern portion of the State, less than one hour's ride by train from New York and Philadelphia.[†] It is irregularly triangular in shape, and is included between latitudes 40° 20′ and 38° 55′, and longitudes 74° and 75° 30′.[‡] It is the northern extremity of the Atlantic Coastal Plain, which extends southward in vast stretches of sandy pine and swamp-lands, to the cocoanut groves and pine-apple fields of Florida. The Coastal Plain of New Jersey is bounded on the southeast by the Atlantic Ocean, on the southwest by Delaware Bay, and on the northwest by a comparatively thickly populated and productive agricultural region. The area of this territory is about 2,500 square miles, at least seventy-five per cent. of which is woods.[*] It is slightly rolling in nature, seldom exceeding two hundred feet above the level of the sea, and is traversed by several navigable rivers[†] besides many small streams.

---

[*] The area of New Jersey is 8,224 square miles, with a population in 1895 of 1,672,942. The area of the Grand Duchy of Baden, an important forest state of the German Empire, is 5,821 square miles, with a population of 1,657,867. It is considerably smaller than the Kingdom of Belgium, which contains 11,373 square miles, with a population of 6,195,355.

[†] The combined population of adjacent cities amounts to more than five millions!

[‡] This region lies in about the latitude of Naples, Constantinople and Northern Japan. Although South Jersey has the temperature of Northwestern Europe, it enjoys the sunshine of Italy.

The climate of this region, although close to the ocean, is, in comparison with that of Western Europe and the Pacific coast, dry. Our prevailing winds which come from the west are dry. During the hot, dry days of midsummer even wild bushes often die. On the other hand, the destructive effects of strong winds, frost and snow press are very slight.

The East American life zones, each characterized by certain forms of life, extend westward with exceedingly irregular and broken borders. There is a transition belt in which the North and the South more or less overlap. This is the true agricultural part of Eastern North America, where apples, white potatoes, barley and oats attain their highest development. It is where the oak, hickory, chestnut, liquidamber, white cedar, etc., of the south, meet the white pine, maple, beech, birch, hemlock, tamarack and arbor-vitae of the north. South of this transition belt begins the first of the true Southern zones, the Carolinian, to which the Coastal Plain of New Jersey belongs.[‡]

A very large percentage of the Carolinian life zone is forestal. Owing to its immense size and to the nature of the agricultural crops which it produces, and for which there is only a limited demand, a large proportion of this zone is destined to remain in forest for many years to come. The Boreal and Austral zones are forestal, the Transition zone agricultural. The eastern part of the Transition zone, from the Dakotas to the sea, although at present agricultural, was formerly the great white-pine region of North America. The white pine of the Transition zone and the short-leaf pine of the Carolinian zone meet on the edge of the Coastal Plain of New Jersey.

---

[*] The term "forest" is seldom used by woodmen. Good or bad, big trees or bushes, it is all called "woods," which is a good generic name for such nondescript lands. The word "forst," from which comes "forest," is a pure Germanic word. From the earliest times it has been applied however to woods which have been protected and regulated.

[†] It is easy to secure an abundance of water in this region, which is a very important feature from a cultural standpoint. In addition to many streams, a natural copious flow may be obtained from artesian wells, so that in places irrigation is easy and practical.

[‡] The Coastal Plain of New Jersey is a northern extension of the Carolinian belt into the Transition Zone. It is in reality a part of the South in the North, and as Prof. Merriam says: "When such farms occupy suitable soils in thickly inhabited regions, so their products may be conveniently marketed, they are of more than ordinary value, for the greater the distance from its area of principal production a crop can be made to succeed, the higher price it will command. Hence, farms favorably situated in northern prolongations or islands of southern zones, or vice versa, should be worth considerably more per acre than those situated within normal parts of the same zones. The obvious reason is that by growing particular crops at points remote from the usual sources of supply, and at the same time conveniently near a market, the cost of transportation is greatly reduced and the profit correspondingly increased."

The Carolinian zone is characterized by the short-leaf pine (*Pinus echinata*), sassafras, persimmon, liquidamber, magnolia, white cedar (*Chamæcyparis thyoides*), cardinal bird, opossum,[*] grape, English walnut,[†] sweet potato, etc. On its southern borders the long-leaf pine (*P. palustris*), the old-field pine (*P. tæda*),[‡] the bald cypress (*Taxodium distichum*) and the southern magnolias appear. In this zone[§] the white cedar (*C. thyoides*) and short-leaf pine (*P. echinata*) reach their optimum.[‖]

Throughout the entire mainland of the Coastal Plain of New Jersey very light sandy soils predominate, although there are many beds of heavy clay, and ridges of road-gravel, also sand and clay loams and vast stretches of mucky swamp-lands. The higher portions of the upland are usually gravelly, the intermediate sandy, and the lower, loamy and clayey. The farther south the richer the soil and of course the thriftier the forest growth. The gravel is yellow and consists of small water-worn quartz pebbles mixed with sand and clay. When of the proper mixture and consistency, it is an excellent and inexpensive road material. The abundance of such gravel in a country where the natural roads are bad is a fortunate coincidence. When sand and gravel are cemented together by compounds of iron, as is often the case, a durable conglomerate is formed, which is the principal building-stone of the region.

---

[*] The oppossum (*Didelphys virginiana*), about which so much has been written because of its marsupial pouch and peculiar habit of feigning death, is arboreal in habit, with hand-like feet and prehensile tail, and is fond of the fruits of the persimmon tree, the seeds of which it is instrumental in distributing. It is highly esteemed as food, especially by the negroes of the South.

[†] East of the Rocky mountains the Persian walnut has been most successful in a limited area along the Atlantic coast from New York southward through New Jersey, southeastern Pennsylvania, central Virginia, North Carolina and Georgia. Farther south it does not succeed, owing mainly to the depredations of microscopic worms, which cause a disease commonly known as "root-knot."

[‡] One specimen of *Pinus tæda* was discovered by Mr. Pinchot, and another by Mr. Arthur Hollick, in Southern New Jersey. The region of the Pokomoke river, on the peninsula between the Delaware and Chesapeake, is, as far as I have been able to observe, the most northern limit of the natural growth of the bald cypress.

[§] According to the investigations of the U. S. Biological Survey (see "Laws of Temperature Control of the Geographic Distribution of Terrestrial Animals and Plants," National Geographic Magazine, Vol. VI, December, 1894), the northward distribution of terrestrial animals and plants is governed by the sum of the positive temperatures for the entire season of growth and reproduction, and that the southward distribution is governed by the mean temperature of a brief period during the hottest part of the year. According to Prof. Merriam the species of the Carolinian belt require a total quantity of heat of at least 6,400° C. or 11,500° F., but apparently cannot endure a summer temperature the mean of which for the six hottest consecutive weeks exceeds 26° C. or 78.8° F. The northern boundary of this zone, therefore, is marked by the isotherm showing a sum of normal positive temperatures of 6,400° C. or 11,500° F., while its southern boundary agrees very closely with the isotherm of 26° C. or 78.8° F. for the six hottest weeks. The minimum temperature was assumed to be 6° C. or 43° F., that is, the point where metabolic processes are just possible.

[‖] By optimum is meant the combination of conditions that produces the best average result.

The sources of the rivers of the Coastal Plain are on its northwestern edge. The land slopes gradually to the sea, and is so level that tide-water penetrates far into the interior. Drainage is therefore good, and stagnation of standing water only occurs here and there in places which are underlain with an impermeable hardpan.

The Plains* are extensive, practically treeless regions in the northern part of the Coastal Plain. The region called the East Plains contains 6,662 acres, and the West Plains 7,737 acres. There are other areas of the same nature, so that 20,000 acres is a conservative estimate of the amount of land of this kind. These Plains are hilly, about one hundred feet in height, and with gentle slopes. The surface soil is usually a bleached sand. Often there is a subsoil of clayey loam and gravel at varying depths. Often the subsoil is hard-pan, and in places there are beds of conglomerate and strata of clay. There is practically no physical difference between the soil of the Plains and the soil of thousands of acres in the neighborhood on which trees of good dimensions are growing. Owing to the hilliness of the region in comparison with the surrounding country, and owing to the lack of a more extensive cover, the soil has been subjected to the leaching and beating of rain and the scorching and drying effects of the sun and wind. One would expect to find it, therefore, exceedingly poor in quality, with a dearth of plant food, which might, at least in part, account for the absence of a more

---

* The term "plain" is usually applied to broad stretches of country which are level or undulating. Owing to the fact that vast treeless areas in the West are called "The Plains," treelessness is popularly associated with the word "Plain." For this reason, no doubt, certain treeless regions in New Jersey are called "The Plains," although they are hillier than the surrounding country. Geographers, however, apply the term to level regions regardless of their cover; for instance, "the Atlantic Coastal Plain." It is worthy of note in this connection that the people of the West distinguish between the "Plains" and "Prairies." The term "Prairies" is applied to the region between the 104th meridian and the eastern base of the Rockies. Their treelessness is mainly due to a lack of moisture. East of this are the "Plains," a fertile but formerly treeless region. The absence of trees is here due rather to the extreme fineness of the soil or to fire and grass than to moisture conditions. Wherever a plain is produced by fire reforestation is possible, but in regions where treelessness is due to a lack of moisture, afforestation is difficult and often impossible without irrigation.

GEOLOGICAL SURVEY OF NEW JERSEY
REPORT ON FORESTRY

Plate No. XVIII.

extensive growth. A chemical examination disappoints one in this respect. Very little dependence, however, can be put in the analysis of a soil. Although the essential ingredients may be present in sufficient quantity, they may not be in available form. A soil may be physically and chemically good, but if moisture is insufficient, the forest will be light and commercially of little importance.

The Plains are covered with a low bushy growth of several species. The highest tree (a sassafras) measured in this whole region was fifteen feet (four and one-half metres). The most peculiar feature of this area is the fact that a large part of the growth is a coppice of pine. By the natives these short, stunted pines are called "she-pines."[*] They are the stump-shoots of *Pinus rigida*, commonly called the rough-bark or pitch-pine. When this pine is cut many shoots sprout from the stump, but since insects soon attack and devour it, the young shoots usually die in consequence while still small and tender. There is a strong tendency in the pitch-pine, *Pinus rigida*, to send out shoots, especially when growing under adverse conditions. Soon after a fire, with the foliage completely burned, and the bole girdled, many dormant buds in the crown and on the trunk develop into shoots, which soon, however, wither and die. Even logs which have been cut and hauled to the mill send out similar shoots. These, of course, wither and die just as soon as the starchy materials and moisture in the trunk are exhausted. The poorer the soil, and more adverse the conditions, the stronger seems the tendency to sprout from the stump. Sprouting in this way is rare among the conifers, and, although of interest botanically, is commercially of no significance whatever. Ordinarily a pine coppice is short-lived, but on the Plains it has persisted for many years. Fire sweeps over this region frequently and burns the shoots while still only a few feet high, but the stump, gnarled, charred and full of pitch, continues to live. Some of the stumps appear to be more than a hundred years old and are not more than five or six inches in diameter. Hard and prickly cones are produced in large numbers with imperfectly formed seeds. *Quercus pumila*,* the scrub or bear-oak, and the Jersey laurel † (*Kalmia latifolia*), are abundant. There are also many interesting herbaceous plants or low shrubby plants, such as the pyxie, the bearberry and the trailing arbutus.

---

[*] The term "she-pine," or "she-pitch-pine," is also applied to *Pinus heterophylla*, which grows in the region of the Gulf of Mexico. In the language of the natives, the prefix "she" indicates not sex but inferiority and imperfection. *P. heterophylla* has been regarded by the lumbermen as a tree of very inferior quality and of little value in comparison to the true southern pitch-pine, *P. palustris*. In the same way the term "she balsam-fir" is applied to *Abies fraseri*, a small, short-lived tree which inhabits only the high slopes of the Alleghany Mountains in Carolina and Tennessee. For the same reason the adjective "bastard" is often applied to trees.

The only tradition attached to these wind-swept, sun-scorched plains is that they have always been treeless. They are often dreary and black from the effects of fire, but soon Nature covers them with a blanket of green, and they glow in season with the bloom of wild flowers. It is always, however, a lonely place, and is seldom visited save by natives, who come to gather the stumps of the pines, which are full of pitch and excellent for fuel.

The Plains's condition is mainly due to fires, which are very common, and which have doubtless burned for many years, probably since the days of the Indian who often passed that way en route to the sea-shore. In the Coastal Plain, all gradations from a healthy pine forest to the scrubby plains may be seen. In fact, through the effects of fire other regions are rapidly becoming plains-like in character. This particular region has first become plains, because it is hilly and higher in altitude. It suffers more from drought, and in consequence has been more easily changed by fire. It is not unlikely on the other hand that the Plains have never been forested and that for ages Nature has been striving to cover them with trees, but fails owing to fires and the dryness of the soil. The plains region was referred to by early travelers, and appears to have changed very little in appearance in the course of time.

---

* The scrub or bear oak (*Quercus pumila* formerly *Q. ilicifolia*) is very common but never reaches the dimensions of a tree. It endures extremely adverse conditions and bears immense quantities of small acorns. It is an excellent protection to the soil which would be otherwise bare, although it furnishes food for fires. Its mast is relished by swine and other animals. It is sometimes cut for umbrella handles and canes. Many of these scrub-oak regions are excellent places for pheasantries. Both the partridge (*Colinus virginianus*) and the pheasant (*Bonasa umbellus*) are fond of its acorns. The Heath or the Prairie Hen (*Tympanuchus cupido*), which is now extinct except on Martha's Vineyard Island, inhabited, it is said, the Plains of New Jersey up to 1868. Although not introduced for forestry purposes, the scrub-oak is quite common in parts of France.

† The laurel is a beautiful evergreen, slow-growing shrub, which thrives on barren land in spite of fire. The rich white and pink corymbs of this plant mixed with its coriaceous leaves are abundant and attractive. In rich damp woods it often reaches the dimensions of a small tree, and its wood, as with the crooked limbs of the red cedar, is extensively used in the construction of "rustic work," a term applied to fences, pavilions and garden furniture made of the crooked limbs and roots of several species of trees and shrubs.

The easiest way to visit the Plains is from Chatsworth, formerly Old Shamong,* on the New Jersey Southern Railroad, which traverses the pineries for many miles.

Surrounding the Plains on all sides and extending far to the southward is an immense tract of land called the Pine Barrens. The term is usually applied to the sandy regions of New Jersey which are covered with a sparse growth of pine, under which, as a rule, there is a scrubby growth of oaks and ericaceous plants. The physiognomy of this region is mainly due to fires and careless cutting. In a few places which have been protected there are magnificent forests of smooth-bark pine and even merchantable oak, in spite of the sandy nature of the soil. In a few of these forests affected only by surface fires, which burn quickly over the thin-covered soil, the ground is white and clean. In other instances where there have been no fires at all, although these spots are few and far between, there is a stand of tall, clean, smooth-bark pine (*P. echinata*), with a good mixture of deciduous trees.

In the spring, when there is a richness of bloom and beauty, and during the Indian summer, when the woods are gorgeous with autumnal tints and enlivened by the chatter of birds feeding upon the harvest of berries, fruits and seeds, the atmosphere of the Pine Barrens is balmy and fragrant. The winter also is pleasant, owing to the freshness of the evergreens and the dryness of the soil, but in summer the sand is hot and dry and the air is full of pestiferous flies and mosquitos and hazy with smoke from forest fires.

In early times settlers cleared the land along certain thoroughfares, irrespective of its quality. Soon many of their farms became barren, and, with a change of industries, they changed their homes and abandoned their fields. When a sandy field in the Jersey pine land is abandoned to Nature, she clothes it at first with a sparse covering of lichens, Indian grass, briars and other pioneer herbaceous and shrubby plants. Soon scattered

---

*** The habit of changing the names of towns in Southern New Jersey simply because the old names sound inelegant is a great pity The word Shamong is an old Indian name. Good old-time names, especially those of Indian origin and those with local color, should never be changed. Such names as Tar-Kiln-Neck, Blue Anchor, Double-Trouble, Long Coming, Penny Pot, Old Martha, Calico, etc., etc., are far more appropriate to the region than Cologne, Pasadena, Iona, Malaga, etc., etc.**

red cedar (*Juniperus virginiana*) and holly (*Ilex opaca*) appear as forerunners, the seeds of which have been dropped by passing birds. The persimmon and sassafras, hardy oaks, and wild-cherry (*Prunus serotina*) also spring up, and near the sites of old dwellings are clumps of the tree-of-heaven (*Ailanthus glandulosus*) growing with tropical rankness, root suckers from the old trees which were once in favor for shade and ornament; now and then also an old sycamore with serpent-like limbs; here and there pines appear, the edges gradually close in on the field, the solitary forerunners become surrounded by their progeny, the gaps are slowly filled by whatever may chance to fall by the many natural means of seed distribution. Thus, in time, the whole becomes a mixed forest of many species and of all age classes: here a thicket, there a pole-wood consisting of softwood and hardwood, evergreen and deciduous sorts, many sickly suppressed trees and many much branched, rough and knotty trees which were the forerunners, holding their own in the struggle for life even against their own progeny. Soon come axe and fire; the weaker kinds perish, the best are used, and a few pines and a coppice of hardy oak alone remain. Sometimes, if surrounded by pine, these old fields come up in a growth of pine as thick and green as a field of grain.[*]

The forests of the eastern United States are possessed of marvelous regenerative power. Among the hundreds of native species there are many capable of great endurance, and, indeed, in the regions east of the western prairies there are few spots so sterile and inhospitable that one or more of these species cannot survive. There is abundant material for the development of new and elaborate systems of silviculture suited to the conditions and needs which exist.

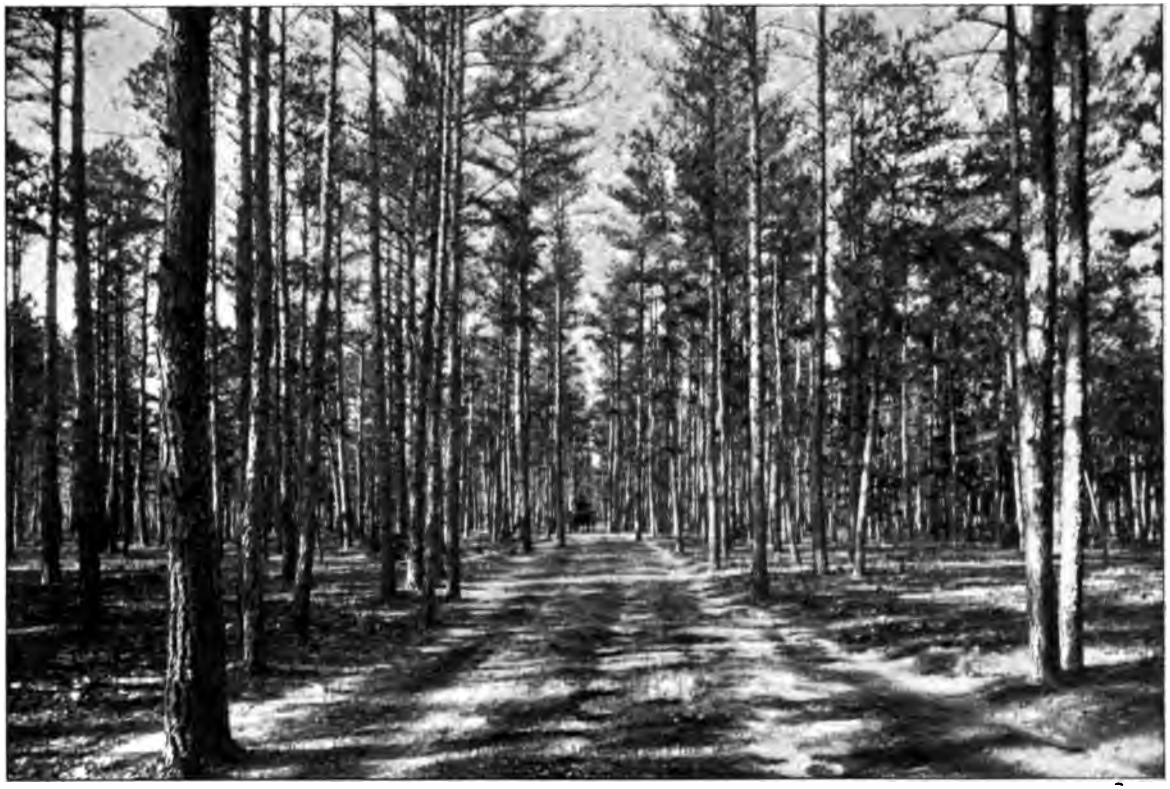
A very large part of the Pine-Barren district is oak coppice. The area in pine, however, is constantly decreasing, the area in oak increasing. Oak of some kind almost invariably follows

---

[*] One must not too hastily conclude that the majority of the Jersey pines are pitch or Indian pines (*P. rigida*). A careful census of many districts will show, especially in the southern counties, that the short-leaf pine predominates. Although the pitch-pine endures fire to a greater extent, the short-leaf pine is more prolific. From a forestal standpoint, this is, in spite of everything, a hopeful condition of affairs, because, as I shall endeavor to show later, there is no coniferous forest tree of the dry sandy portions of the Carolinian zone which is silviculturally and commercially the equal of *Pinus echinata*, the short-leaf or smooth-bark pine.

GEOLOGICAL SURVEY OF NEW JERSEY
REPORT ON FORESTRY

Plate No. XIX.



THE PINES AT LAKEWOOD

pine. Throughout every pine woods are scattered here and there suppressed oaks, the seeds of which may have been dropped by jays or chickarees. Just as soon as the pines are cut, these oaks, owing to increase of light and room, grow quickly. In spite of the poverty of the soil and the inroads of insects, and although burnt and cut again and again, they show remarkable vigor.*

Even scientific men have advanced the theory that one species of tree follows another because the first exhausts certain ingredients in the soil which it must have and which another species may not need. Such statements are rarely founded on facts. The reason one species follows another may be easily determined in almost every case with a little observation and study. Trees do not generally exhaust the soil, but, by bringing inorganic materials from deep layers of the soil and depositing these in the form of litter on the surface, and by protecting it from the beating and leaching of rain and scorching effects of wind and sun, improve its quality. In moist pine regions which have been burnt over several times and on which everything is killed, birch often springs up in an almost magical way. This is due to the facts that the seeds of the birch are quickly distributed by the wind and quickly germinate, and that the birch is capable of living on extremely poor soil.

Many dry leaves cling to the small oak trees until the following spring;† the limbs reach close to the ground, and fire, therefore, in the late winter or early spring, before there is much sap in the wood, kills them, although the stumps live on, and with great persistency produce a fresh growth. In the struggle for existence the scrub oak and the black jack (*Q. marilandica*) usually survive. Although these two oaks are of slight economic importance, it is due to their pertinacity that in many places the soil has been prevented from shifting. The species which form this coppice are, post oak (*Q. minor*), black oak (*Q. velutina*), white oak (*Q. alba*), chestnut oak (*Q. prinus*), Spanish oak (*Q. digitata*), red oak (*Q. rubra*), black jack (*Q. mari-*

---

* It is well known, however, that oaks, chestnuts, and similar trees, lose their vitality when asexually reproduced for a great length of time.

† It has been suggested by botanists that these clinging leaves indicate a tendency or are a step toward the evergreen state. The magnolia glauca is almost evergreen in Southern New Jersey. When leaves cling in this way it is an indication that the species is frost-tender and that the leaves were injured by frost before the normal corky layer was formed at the base of the petiole.

landica), and scarlet oak (*Q. coccinea*). Hybrids and irregular forms are common. The coppice is usually cut as pole-wood for fuel, and has little value. Owing to careless cutting the stumps are apt to be partly decayed. This decay spreads to the tree. It also invites the inroads of insects, the number of which injurious to these oaks is legion.

The wonderful rapidity of tree growth in this sandy soil is often remarked with surprise. Bleached white as snow, and, apparently, absolutely destitute of plant food, it is nevertheless capable of supporting a thrifty arboreal growth. The young tree starts with the greatest difficulty and languishes throughout the early part of its life, but as soon as its roots have reached the deeper and richer layers of the soil it starts afresh and grows thenceforth with astonishing rapidity. The soil is porous, and although well drained, is moist a short distance below the surface, The lay of the land and the nature of the soil is such that the roots of trees can in the majority of cases penetrate to where there is constantly sufficient moisture. From the Plains, the highest part of the Coastal Plain, there are naturally all degrees of soil-moisture conditions, through the Pine Barrens to the swamp lands.

A swamp is usually defined as a tract of land with or without trees, lower than the surrounding country, and so saturated with water as to be unfit for cultivation.

This definition, however, is insufficient. When one speaks of a swamp in Southern New Jersey, or in any part of the Southeastern States, a wooded region is usually meant. A swamp, also, is not always unfit for cultivation. Some of the best farm land in America is on swamp bottom. Neither is it always lower than the surrounding country. Elevated swamps are common, and the Dismal Swamp of Virginia and North Carolina, which is like a Jersey swamp in many respects, is several feet higher than the surrounding country, with a lake in the center from which water runs in all directions.

The amount of water in a swamp is an important matter, also the temperature of the water. It varies in amount from a degree of mere moistness to the condition of the Cypress swamps of the south, which are at times navigable for canoes, bateaux and often good-sized scows. Along the Mississippi river there is a vast region called the River-swamp, which is seldom completely flooded. Here, several of the trees which grow in southern New Jersey reach their optimum. Many trees which thrive in water in the south cannot live in the swamp-lands in the north, because of their coldness, but thrive on the upland. By the term swamp is merely meant a wet, muddy region, covered with a wild growth of trees and bushes.

To wet, almost treeless or treeless areas, the terms savanna, morass, bog, slough and marsh are applicable. The term savanna is usually applied to lowlands covered with grasses and other herbaceous plants; the terms morass and bog, to extremely spongy, sphagnaceous lands; and the term marsh, to the soft, muddy deposits around and along bodies of both salt and fresh water. Some are inclined to restrict the term marsh to those areas formed in salt water. There is little reason for this, since salt and fresh marshes are essentially alike in formation. All these terms are, unfortunately, exceedingly elastic in meaning. A cedar swamp, for instance, is a swamp while covered with trees, but when cut over, cleared and planted with cranberries, it becomes a bog.

Much of the swamp-land in the Coastal Plain of New Jersey, although merely moist and extremely fertile, will probably remain in woods for many years to come, because of the difficulty in clearing it. A swamp bottom consists of the forest detritus of ages, and is a matted mass of roots, stumps and tree trunks.

The swamp-land may, for the sake of convenience, be divided into cedar swamps and deciduous or hardwood swamps.

The white cedar (*Chamæcyparis thyoides*),* the finest soft wood of the region, grows in dense pure forests. The tree is tall, straight and sharp-pointed. The bases of the crowns meet to form a solid canopy. The trees grow so close that one supports another, and when a few are cut, or felled by storm, others in the neighborhood, deprived of their support, fall in every direction. The limbs are often festooned with a gray lichen (*Usnea barbata*), the pendant tufts of which are favorite nesting places of the Parula warbler (*Compsothlypsis americana*). These swamps are warm and protected in winter, and harbor, therefore, many birds. They are cool in summer and fragrant with the odor of clethra (*C. alnifolia*) and magnolia (*M. glauca*). A cedar-swamp bottom seldom freezes. This may be partly due to the fact that cedar swamps are usually located in regions of springs.

---

* This tree should not be confounded with the white cedar or arbor vitæ of the north (*Thuya occidentalis*).

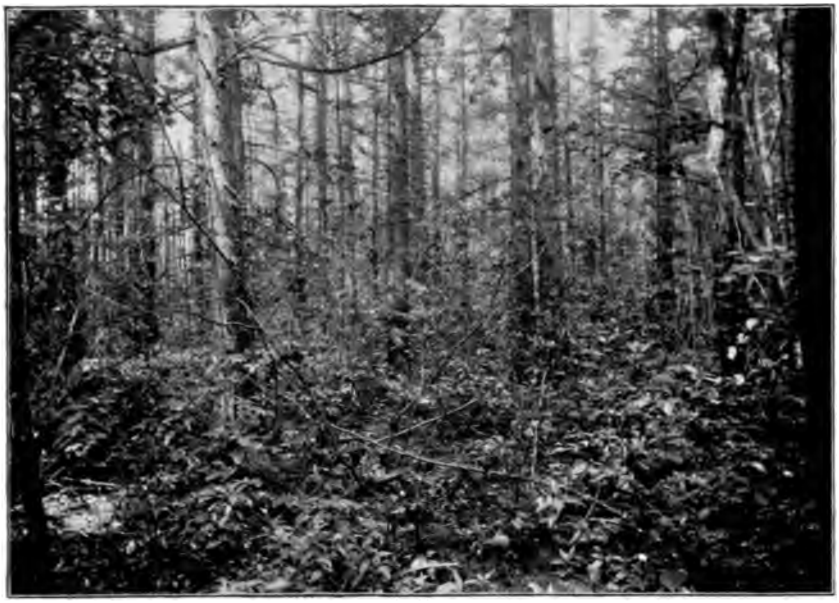
The forest floor is usually covered with a thick mat of spongy sphagnum moss. The streams in passing through the swamps often separate into several streamlets, which meander through the mass of moss and submerged tree trunks and roots. The water of these in dark places is black as ink, but in the light and in shallows is the color of mahogany or amber, owing to impregnations from the humus. Nothing is more characteristic of the Coastal Plain of New Jersey than these swamps of cedar. Although practically the northern limit of this excellent species, it is perfectly at home in South Jersey. Free from disease, and always a fresh rich green, cedar swamps form the most striking feature of the landscape. It is a common saying in South Jersey that a cedar swamp attracts a shower. It seems to be often the case that a thunder storm follows a branch or stream until it reaches a mass of swamp, and there drops its rain.

Owing to the excellence of the wood, these swamps are devoured with avidity by lumbermen. The bottom when not too difficult to clear, and when properly located, is in demand for cranberry bogs.* When a cedar swamp is cut or burnt, if certain conditions prevail, it may come again in cedar, usually, however, deciduous swamp trees, inferior in nature, usurp its place.

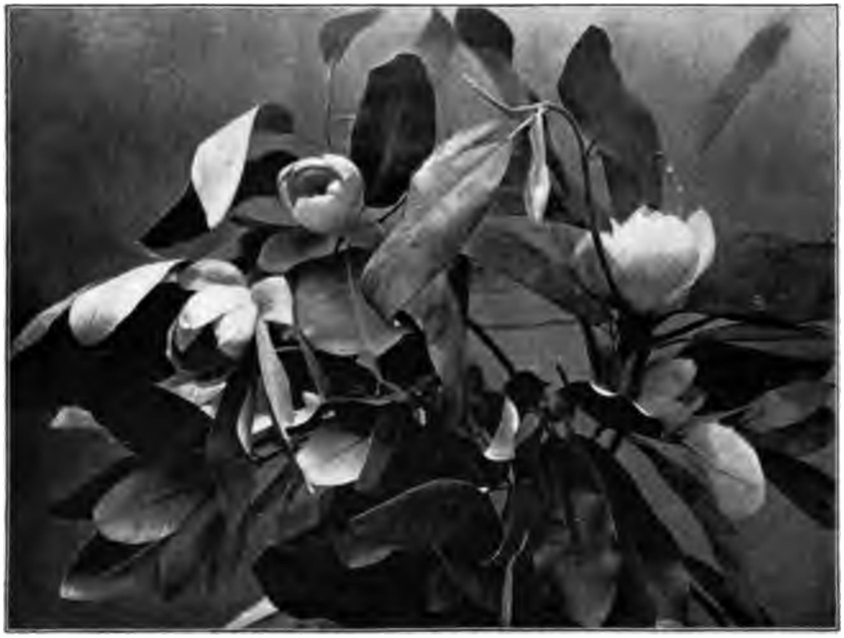
---

* The cultivation of the large or American cranberry (*Oxycoccus macrocarpon*) is a very important industry in South Jersey. The berry, the size of a cherry, grows in large quantities on a low creeping vine, which forms a mat on the surface. The clearing and preparation of these bogs are expensive, but the yields are often enormous, and the bog lasts for many years without perceptible deterioration. The cultivation of this plant requires skill and experience. In times past fortunes have been lost as well as won in the cranberry industry. The amount of fruit yielded year after year by a bog suitably located and tended is often enormous A cedar-swamp bottom through which there is a running stream is selected. This is banked and arranged so that the bog can be easily and quickly flooded, since it is desirable to keep it covered with water throughout the winter and for a short time at other seasons of the year, to protect it from frost, to drown out undesirable weeds and insect pests or prevent a fungous disease called "scald." A bog may be flooded at any time without injury to the vines, except when in blossom In clearing a bog the stumps are usually removed, but not always. The whole is turfed with a cranberry or bog hoe, which has a wider blade than the ordinary grub-hoe. Ditches are dug throughout the whole bog, and sometimes the surface is sanded. It is planted in a simple manner with a suitable variety of wild-berry from the woods or from another bog. Usually the vines are mown down with a scythe These pieces are dropped over the area ready for planting and pushed into the soft soil with a wooden dibble. They soon take root, and in the course of a couple of years their vigorous stolons have complete possession of the soil.

Plate No. XX.



A WHITE-CEDAR SWAMP



MAGNOLIA GLAUCA

The swamp lands* being moist, have naturally not suffered from fire as much as the uplands. They often consist, therefore, not only of a great mixture of species, but are a semi-tropical tangle of wild grapes, and other vines and bushes. The deciduous or hardwood swamps usually contain a mixture of the following trees of more or less importance: *Acer rubrum*, red or swamp maple; *Liquidamber styraciflua*, sweet gum or bilsted; *Nyssa sylvatica*, black or sour gum, and *Magnolia glauca*, or brewster, are the commonest. In some swamps there are beeches (*Fagus latifolia*), tulip trees (*Liriodendron tulipifera*), swamp white oak (*Quercus platanoides*), willow oak (*Q. phellos*), holly (*Ilex opaca*), sassafras (*S. sassafras*), and now and then a pitch-pine (*Pinus rigida*), a smooth-bark pine (*Pinus echinata*), a white cedar (*Chemæcyparis thyoides*) or even a white pine.†

Fire and the axe have converted many of these swamps into sorry looking thickets and cripples,‡ which are little more than tangles of saplings, bushes and vines. It is easy to imagine how, in the course of time, fire, burning over land of heavy nature or land which is usually moist, will gradually kill even swamp trees and shrubs, until nothing remains but herbaceous plants among charred stumps. These swamps often become very dry in summer, and the natives, to improve the quality of the berries (or very rarely the pasturage), set fires. This must be done, however, when the soil is not too dry.* In this way moist swamps become meadows. This land, if left to itself and protected from fires, soon recovers, but there is another kind of grassy land, namely "Savanna," which is of little worth in New Jersey at present, and destined to remain unchanged for many years to come.

---

* It is in these swamps where the animals of the woods take refuge, especially the deer, which, at a certain time of the year when the law allows, are remorselessly chased by packs of hounds. The extinction of this animal in New Jersey is only a matter of time unless the use of dogs is absolutely prohibited at all seasons. It is the prevailing opinion in the Adirondacks that the wisest move in the protection of deer was the prevention of hounding by law. The meat of a hounded animal is poor in quality, to say nothing of the cruelty which the nagging of dogs occasions. Hunting at best is an immoral sport, and in America is everybody's privilege. In every backwoods town there are local social gypsies or pothunters who love sport and hate work, who spend their days wandering in the woods with dog and gun, and their evenings in the country store or tavern relating their experiences. Several animals in South Jersey are hunted not for their pelts or for food but for the bounty which the townships very foolishly pay for the heads of certain so-called "depredatory animals," among the worst of which the fox is classed.

† The white pine was at one time quite abundant in Manahawken swamp. These pines towered high above the cedars of the swamp. This suggests the possibility of growing the white pine in such districts either alone or mixed with white cedar. The choppers whom I consulted at the time of my visit called the white pine "white wood."

‡ The term "cripple" is a localism used in South Jersey and on the Chesapeake peninsula. It is applied to a thicket or bushland. It is interesting to note that the Germans use the word in the same sense. For instance, a stand of trees which has been abused by careless cutting, etc., is called a "Kruppelbestand." Underbrush is sometimes called "Kruppelholz."

The formation of such grass land in New Jersey is usually due to a hard-pan which is often only a few inches below the surface. Hard-pan is the name applied to a dense, almost impenetrable stratum of compacted material. It is generally soil in the process of becoming rock. In these savanna lands † it is bog-ore and organic materials cementing the particles of sand. It is covered by several inches of humus, which is saturated with water and is sour in consequence. Here and there on knolls in these sloughs, a pitch-pine grows, but topples over in the course of time, owing to the slight hold which it has upon the soil. The hard-pan is similar to the "ortstein" of Northern Europe and the "alios" of the French Landes. This stratum exists in all degrees of hardness, and often in sufficient quantities to prevent the growth of trees on considerable areas of land, but in a region where even good wood-land has little value, the comparatively small area of savanna is not worthy of much consideration, because the cost of drainage and preparation would amount to more than the land is likely to be worth for some time to come.

Stretching along the coast of Southern New Jersey and along the Delaware river, fringing the mainland and bays, and extending along the rivers far inland, are many miles of salt marshes. They are of course treeless.‡ In former times these lands were banked and cultivated much more extensively than at present. Owing to the difficulty of keeping the banks in order, they have in large part been abandoned. The marshes, endless to the eye, are intersected by many bays, salt ponds, thoroughfares and winding creeks. They yield thousands of tons of salt hay (*Spartina juncii*), and black grass (*Juncus gerardi*), which are extensively used for fodder and packing. It is transported on flat-boats or scows up the many rivers to the interior, and is also baled and shipped to the neighboring sea-shore resorts and cities. Owing to the fact that these marshes already yield a good income, that is, a fair rate of interest on the amount invested, and probably more than cultivated fields would pay, by producing year after year a good grade of hay without any labor except the reaping, and a little ditching now and then, it would be a precarious investment to bank and drain them as has been done with similar land in Holland, except in the northeastern part of the state, where proximity to cities makes land more valuable than in the southern part. These banked lands, although fertile, are unsatisfactory to till ; the dykes are[*] a constant care and anxiety, and storms and high tides, besides other serious dangers, often cause irreparable damages.

---

* Constant burning causes deterioration of pasturage in the course of time. The weaker grasses are gradually killed. On salt marshes and wild meadows where the soil is very moist, so that the roots are not injured by fire, regular burning is a benefit

† The term savanna is a relic of the Spanish in America and in general merely means a tract of level land covered with low vegetation, usually grass. It is used throughout the world in this sense. In old Spanish the word means a "sheet," and was originally applied to a flat snow-covered region.

‡ In places hardy shrubs and trees are gradually intruding on the marshes as they become by deposit higher and sweeter. In other places groups of trees may be seen which have been killed by too large a dose of salt water.

The reasons for mentioning these marshes in this connection are, firstly, they yield an abundance of fodder and litter, and secondly, the mud is an extremely rich fertilizer, consisting mainly of humus, but containing also lime, and the decomposed bodies of both macroscopic and microscopic organisms. It is an inexhaustible store of fertility. In it are the materials which the sandy soil of the interior needs most. By applying this mud in the fall, so that the frost will pulverize and mellow it, and, the following summer, sowing a leguminous crop for green manure, the sandiest field is rendered so fertile that with intensive culture, including a regular supply of water and intelligent labor, it will produce fruits and vegetables of the finest quality. This litter and mud are abundant and available to all those who have enterprise and energy enough to utilize them.

---

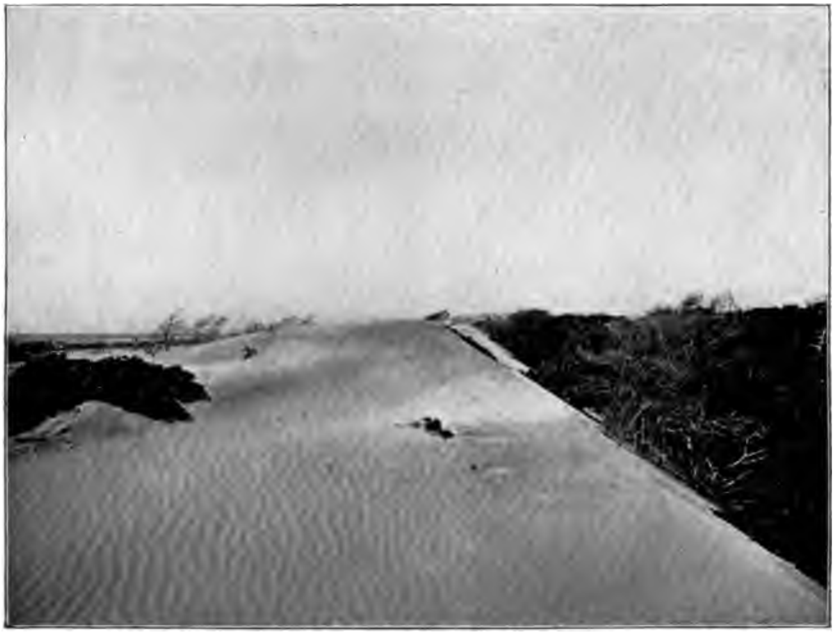
[*] The banks are often seriously damaged by the musk-rat (*Fiber zibethicus*), an aquatic rat-like rodent. It yields a salable fur and is extensively trapped. They dig through a bank in all directions, causing it to leak and weakening it throughout in a way which is difficult to repair. They are prolific and must be combatted in various ways. Many encourage the presence of black snakes (*Bascanion constrictor*), which feed upon its young. A tight hemlock board or slab-fence is often constructed against the face of the bank, or small pilings are driven close together along its outer edge. Ditches should never be dug on both sides of a dyke, if so, the rats are very fond of channeling from ditch to ditch. If sand is used in the construction of the outer part of a bank, rats are less apt to disturb it, because it caves easily and thus interferes with their digging. Willows should be planted on these banks and fascine and wattlework constructed on their faces. The great use of fascine and wattlework is not fully appreciated in America. The banks which worry the Jersey farmer would be little more than play to the enterprising Dutchman who, with patient toil, farms into the very jaws of the sea. He would even look with envious eyes on our shallow inland bays and would soon convert them into many acres of rich polder-land.

The mainland and marine marshes are protected from the action of the ocean waves by a line of barrier beaches or sea islands. These beaches, on which are located many famous resorts, are separated from one another by inlets through which the tide sweeps swiftly. Strictly speaking, a beach is that part of a shore between high and low water, but in New Jersey the term is applied to what are really sea-islands. These islands consist of a fine white sand which in places is mobile. When the tide falls, the sand of the beach proper, dried by the sun and wind, is blown either inland or into the ocean. The prevailing winds blow toward the sea, and the sand as it dries flies back into the water to be whirled again on the beach by the waves. If the wind continues for some time from the sea, sandhills are formed. Any small obstacle sufficient to diminish the energy of the wind may cause the commencement of a dune. As soon as a little hill is formed, it is easy to see how it may continue to form while the conditions remain the same. Soon a strong west wind, however, may hurl it back into the sea, or an eastern gale fling it inland on the marshes. And so it goes, forming and re-forming, changing in fact with every caprice of the wind, gentle and almost unnoticeable during a light sea-breeze, but a stinging, blinding sand-blast in times of gale. In case of an obstruction, which interferes with the action of the wind, a dune forms equal in height to the obstacle. A great deal of the land on these islands is now occupied by resorts; it is all in fact owned by private parties, and is in places extremely valuable. But here and there are tracts of wild, shifting dunes. At Avalon there is a huge dune, caused by a dense forest which is being slowly but surely engulfed. The dune begins just above high-water mark, and then extends inland, gradually increasing in height until its summit is even with the foliage of the trees. It is a peculiar scene from the top of this dune; on the land side there is a dense mass of dark green foliage, beyond which there is the broad expanse of green salt marshes with their bays and thoroughfares.* On the ocean side, sloping to the breakers, there is a huge mass of fine sea-

---

* A waterway from one bay to another is called a "thoroughfare" along the Jersey coast.

Plate No. XXI.



THE CREST OF THE SAND-DUNE ON SEVEN MILE BEACH

cedar. The holly thrives here, reaching a much larger size than on the mainland, apparently enjoying the moist, salt atmosphere and loose sand. It is a dune-tree par excellence. Its limbs are close and jagged, in striking contrast to the pyramidal, symmetrical holly trees of the inland open field. Its prickly foliage is dense and dark green, and its crown is flat. It produces rich red berries in profusion, and its bole is bright gray in color, rugged and sturdy. It is not uncommon to find two hollies grown together, or the limb of one tree growing into another tree, or a limb bending down and uniting with the trunk, forming what the natives call "jug-handles." Those who are familiar with the region will never forget these groups of hollies, nor the masses of aromatic red cedars with limbs festooned with gray lichens. (See plates XXI, XXII and XXIII.)

There is but little danger lurking in these sand-hills. They are, in this respect, unlike the dunes of Gascony, which, if robbed of their forests, would bury villages. The Jersey dunes are so wild and picturesque that many prefer to let them have their way; but the scenes on these beaches, so attractive and peculiar to-day, are destined to lose much of their charm by being transformed into resorts for recreation and pleasure.

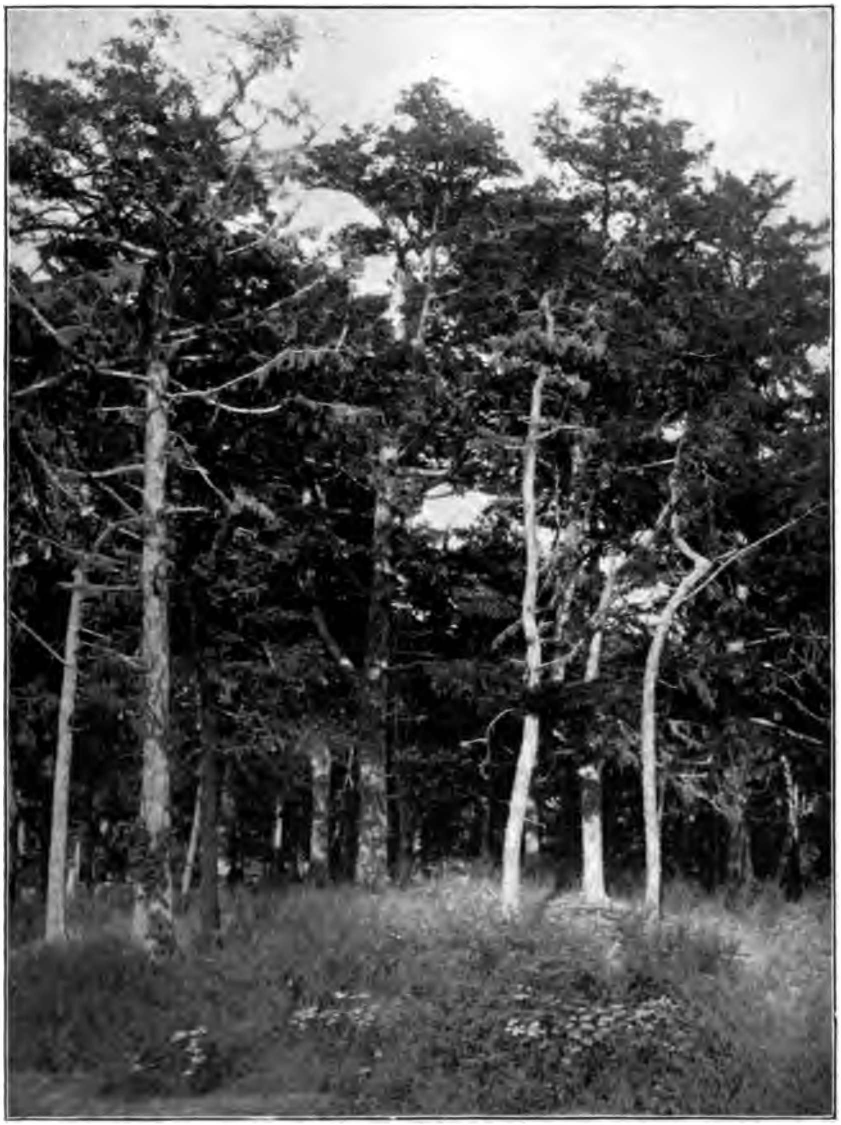
How lacking in shade and attractiveness are our American sea-shore resorts in comparison with those of the Old World! Look at Arcachon (see plate XXVIII), for instance, with its summer village by the shore and its winter village of beautiful villas in the midst of a magnificent pine forest; or at the famous Dutch resort, Scheveningen, with its beautifully shaded avenues; or Domberg (see plate XXV), or anywhere, in fact, in the lee of the dune, which protects the farm-land where the industrious Dutch have beautiful villas in the midst of the woods. Sand-bars and mud-flats should never be despised, and a country close to the sea enjoys many advantages of which its people are not always conscious.

The utilization* of the forests of America began with the Indian. The Coastal Plain of New Jersey, however, was very sparsely inhabited before Europeans landed. Here and there along the rivers may be seen the vestiges of Indian villages, pot-

---

* One often hears and reads the statement that the branch of forestry called "forest utilization" and "lumbering" are synonymous. This is a mistake in that lumbering is no more forestry than the picking of wild fruits is agriculture.

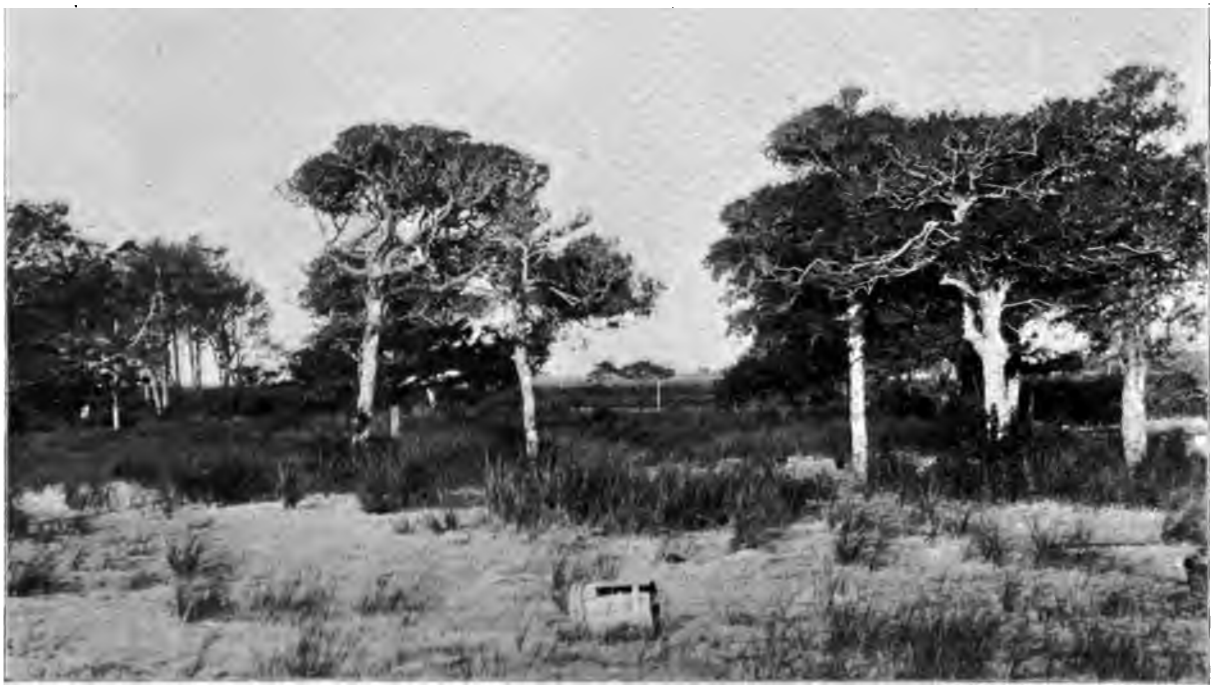
Plate No. XXIII.



A GROUP OF RED CEDARS ON THE COAST OF NEW JERSEY

GEOLOGICAL SURVEY OF NEW JERSEY
REPORT ON FORESTRY

Plate No. XXII.



HOLLIES ON SEVEN MILE BEACH

sand, out of which project the jagged trunks and limbs of smothered trees. The fine sand sifts into shoes, pockets, clothing and hair. It comes fresh from the great ocean-mill, ascends the surface of the dune, and falls over its crest into the forest. When a stiff breeze is blowing it skims along like drifting snow, and shoots from the summit of the dune, trimming the tops of the trees as flat as though shorn with shears.*

If these forests are what cause the dunes, by preventing the west wind from blowing back the sand, how did the forests form? Single trees here and there, or groups of trees, which are clean underneath, so that the west wind sweeps through without serious interruption, do not cause the formation of dunes. In the course of time, however, a thicket forms under these trees. They become covered with grape vines, Virginia-creepers and green-briars. The birds and winds scatter the seeds of many sorts of shrubs and bushes, such as *Prunus maritima*, sweet-gale, *Baccharis halimifolia*, etc., etc., until a dense forest is formed through which the west wind cannot penetrate, the consequence of which, in the course of time, is a dune, which in turn finally engulfs and kills the forest that had caused it.†

It is a mistake to suppose that this sand is sterile because it appears barren. True, it consists mainly of granules of quartz, but these are extremely fine, the interstices are small, and the capillarity great in consequence; mixed with it are particles of shells and other materials, organic and inorganic, which are in the ocean, working down the coast until washed ashore and shifted with the sand.

The forest at Avalon is so dense that many birds seek shelter there. The principal trees of these beaches are the holly (*Ilex opaca*), the red-cedar (*Juniperus virginiana*), the sour or black-gum (*Nyssa sylvatica*), magnolia (*M. glauca*), wild-cherry (*Prunus serotina*), hackberry (*Celtis occidentalis*), sassafras, swamp-maple (*Acer rubrum*), and a few oaks, and pitch-pines and even red-mulberry. The commonest, and by far the most characteristic, trees of the beaches are the holly and red-

cedar. The holly thrives here, reaching a much larger size than on the mainland, apparently enjoying the moist, salt atmosphere and loose sand. It is a dune-tree par excellence. Its limbs are close and jagged, in striking contrast to the pyramidal, symmetrical holly trees of the inland open field. Its prickly foliage is dense and dark green, and its crown is flat. It produces rich red berries in profusion, and its bole is bright gray in color, rugged and sturdy. It is not uncommon to find two hollies grown together, or the limb of one tree growing into another tree, or a limb bending down and uniting with the trunk, forming what the natives call "jug-handles." Those who are familiar with the region will never forget these groups of hollies, nor the masses of aromatic red cedars with limbs festooned with gray lichens. (See plates XXI, XXII and XXIII.)

---

* I am of the opinion that the shapes of trees along our coast is due more to the sand-blast than to the direct action of the wind. This also limits the number of species. Those plants with foliage best able to withstand this sand-blast are the ones which grow nearest the sea.

† By clearing away the underbrush and trimming the trees to let the west wind through, it might be possible in several places along the coast to dispel the dunes and prevent their future formation.

There is but little danger lurking in these sand-hills. They are, in this respect, unlike the dunes of Gascony, which, if robbed of their forests, would bury villages. The Jersey dunes are so wild and picturesque that many prefer to let them have their way; but the scenes on these beaches, so attractive and peculiar to-day, are destined to lose much of their charm by being transformed into resorts for recreation and pleasure.

How lacking in shade and attractiveness are our American sea-shore resorts in comparison with those of the Old World! Look at Arcachon (see plate XXVIII), for instance, with its summer village by the shore and its winter village of beautiful villas in the midst of a magnificent pine forest; or at the famous Dutch resort, Scheveningen, with its beautifully shaded avenues; or Domberg (see plate XXV), or anywhere, in fact, in the lee of the dune, which protects the farm-land where the industrious Dutch have beautiful villas in the midst of the woods. Sand-bars and mud-flats should never be despised, and a country close to the sea enjoys many advantages of which its people are not always conscious.

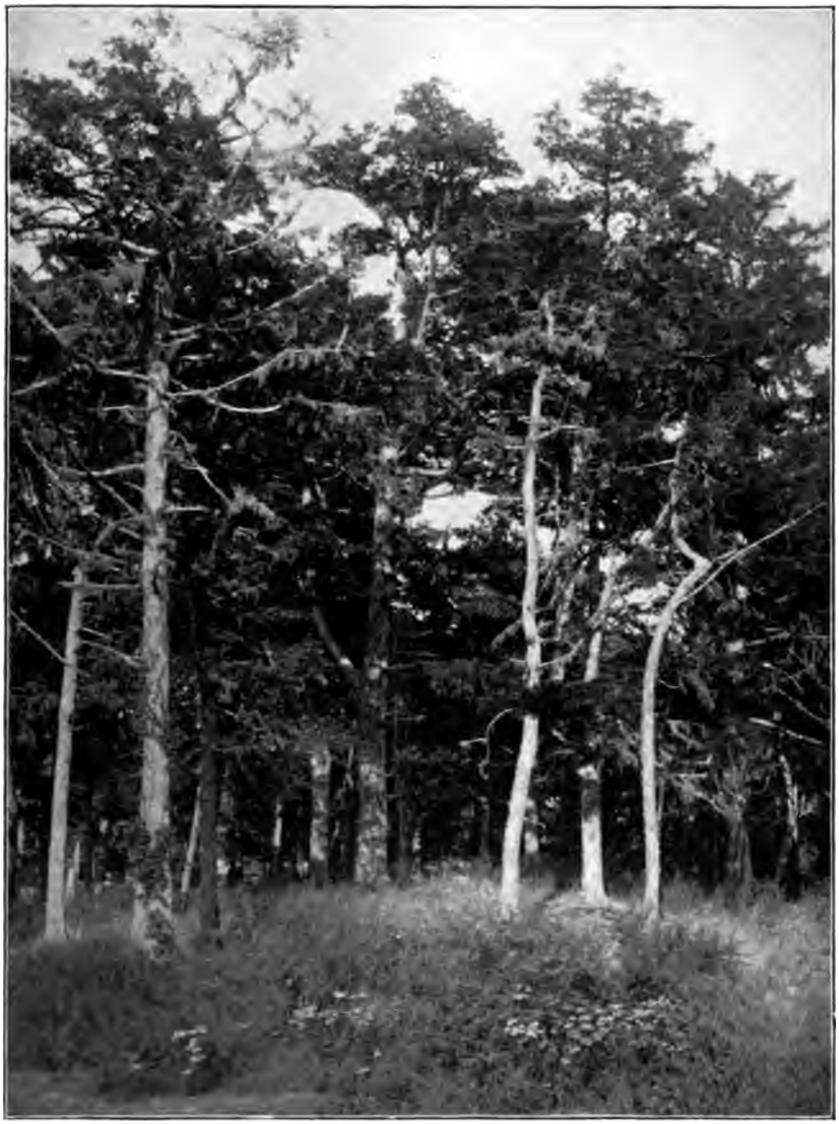
The utilization[*] of the forests of America began with the Indian. The Coastal Plain of New Jersey, however, was very sparsely inhabited before Europeans landed. Here and there along the rivers may be seen the vestiges of Indian villages, pot-

---

[*] One often hears and reads the statement that the branch of forestry called "forest utilization" and "lumbering" are synonymous. This is a mistake in that lumbering is no more forestry than the picking of wild fruits is agriculture.

GEOLOGICAL SURVEY OF NEW JERSEY
REPORT ON FORESTRY

Plate No. XXIII.



A GROUP OF RED CEDARS ON THE COAST OF NEW JERSEY

cedar. The holly thrives here, reaching a much larger size than on the mainland, apparently enjoying the moist, salt atmosphere and loose sand. It is a dune-tree par excellence. Its limbs are close and jagged, in striking contrast to the pyramidal, symmetrical holly trees of the inland open field. Its prickly foliage is dense and dark green, and its crown is flat. It produces rich red berries in profusion, and its bole is bright gray in color, rugged and sturdy. It is not uncommon to find two hollies grown together, or the limb of one tree growing into another tree, or a limb bending down and uniting with the trunk, forming what the natives call "jug-handles." Those who are familiar with the region will never forget these groups of hollies, nor the masses of aromatic red cedars with limbs festooned with gray lichens. (See plates XXI, XXII and XXIII.)

There is but little danger lurking in these sand-hills. They are, in this respect, unlike the dunes of Gascony, which, if robbed of their forests, would bury villages. The Jersey dunes are so wild and picturesque that many prefer to let them have their way; but the scenes on these beaches, so attractive and peculiar to-day, are destined to lose much of their charm by being transformed into resorts for recreation and pleasure.

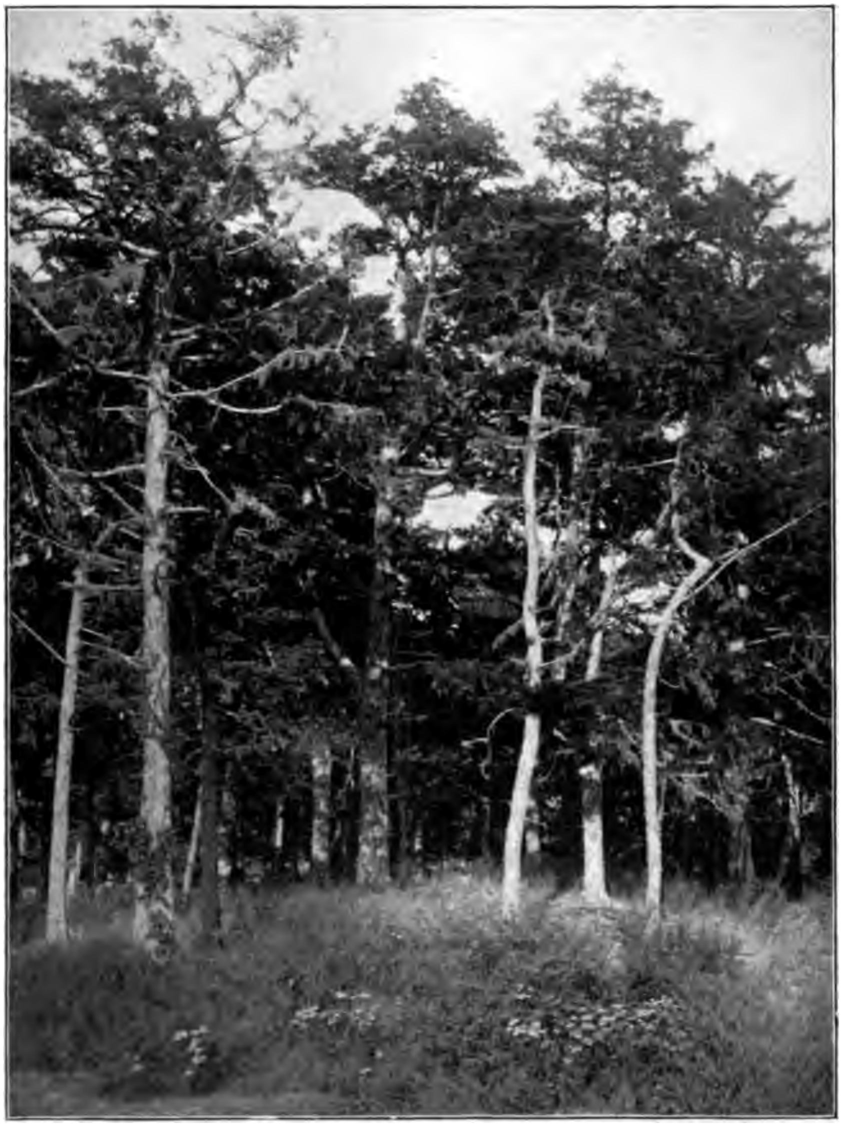
How lacking in shade and attractiveness are our American sea-shore resorts in comparison with those of the Old World! Look at Arcachon (see plate XXVIII), for instance, with its summer village by the shore and its winter village of beautiful villas in the midst of a magnificent pine forest; or at the famous Dutch resort, Scheveningen, with its beautifully shaded avenues; or Domberg (see plate XXV), or anywhere, in fact, in the lee of the dune, which protects the farm-land where the industrious Dutch have beautiful villas in the midst of the woods. Sand-bars and mud-flats should never be despised, and a country close to the sea enjoys many advantages of which its people are not always conscious.

The utilization* of the forests of America began with the Indian. The Coastal Plain of New Jersey, however, was very sparsely inhabited before Europeans landed. Here and there along the rivers may be seen the vestiges of Indian villages, pot-

---

* One often hears and reads the statement that the branch of forestry called "forest utilization" and "lumbering" are synonymous. This is a mistake in that lumbering is no more forestry than the picking of wild fruits is agriculture.

Plate No. XXIII.



A GROUP OF RED CEDARS ON THE COAST OF NEW JERSEY

sherds, broken shells, bones and bits of jasper. At certain times of the year large numbers crossed the State to enjoy for a time the bathing and fruits of the sea, but the permanent population was never large. The Indian of New Jersey domesticated no animals and cultivated only a few plants. His clumsy stone implements were so unwieldy and impotent that he was unable to exterminate animals or cut down forests.* He depended mainly upon the fruits and animals of the woods. He needed only wood for fuel, which was everywhere plentiful, and white-cedar logs, out of which to shape his canoes. The rivers were his highways, the canoe his conveyance. Fires, no doubt, were set both accidentally and purposely by the Indian, but in Southern New Jersey they were probably infrequent, and did comparatively little damage. Indians in parts of Western America still fire the bush† to facilitate hunting. They desire open prairies and intervales for their game. In many places east of the Mississippi river, after the Indians departed, prairie fires which they had purposely set every year, became less frequent, and forest vegetation in consequence began to appear in the open land.

He has left his impress upon the country however, and Indian words are indelibly attached to many localities, and to the names of many plants and animals, such as persimmon, chinkapin, hickory, tamarack, mahogany, pecan, etc.

Although the Algonquin Indian of New Jersey was dependent upon the forest and still in a primitive state, he cultivated small patches of maize and perhaps other vegetables, and was familiar with the edible wild plants. From the Indian the whites learned of a tree (*Acer saccharum*) with a sweet palatable sap‡ that grew in the northern mountains. The settler, in times of famine, often appealed to the Indian, and many of the fruits and vegetables upon which he fed have been since neglected. The Indian-club and the Indian-fig, for instance, two of his important food-plants, are perhaps worthy of cultivation and improvement.*

---

*"The chief use of the hatchets among the Delaware Indians of New Jersey," says Kalm, "was to make good fields for maize plantations. If the ground was covered with woods, they cut off the bark all round the trees with their hatchets at a time when they lose their sap. The trees thus girdled died, and the ground was a little turned up with crooked or sharp branches."

†The term "bush" is a peculiar one. It usually means a single low woody plant. In certain regions, however, it is applied to a wild forest with a dense underbrush. The sugar maple forest or orchard is sometimes called the "sugar-bush." The word in Dutch is "bosch," and means forest, and, no doubt, the Hollanders were the first to apply it in this sense in South Africa and America. The word "bois" in French and "bosco" in Italian are probably modifications of the same word. There is an old English word "boscage," which means a thicket or woodland growth. In old English law boscage meant food for cattle derived from trees or bushes, also a tax on wood brought into a city.

‡Col. Wm. Fox, in his paper on the maple-sugar industry, in the latest report of the New York State Forest Game and Fisheries Commission, says: "For our first knowledge of this product we are indebted to the North American Indian, the same people who gave us corn and tobacco. From the records of the earliest explorers on this continent it appears that the Indians tapped the maples, gathered the sap in rude receptacles, and boiled it. The first white settlers used the same methods, which substantially remain unchanged to day."

The Indian of New Jersey was soon superseded by the settler, who, provided with two powerful implements—the axe and the gun—cleared small patches of land, and built cabins along the rivers. Trapping was the settler's first occupation and peltry † was one of the first and most important products of the virgin forest. Hunting and trapping in early times were hazardous, but often lucrative occupations. The forest was difficult to clear, and just as the young poplars to-day harass the New England farmer, by invading his pastures, and the mink and fox rob the hennery, so in early times a hundred-fold more bothersome were the suckers and seedlings, and animals from the woods between the clearings. Fire was freely used, and from the ashes potash was extracted by leaching. This lixivium, by mixing with grease produced soft-soap, which is still manufactured by country people. In many places to-day wood is extensively burnt for its ashes and used as a fertilizer.

Soon shipbuilding developed into an important industry. Oak and pine of the finest kinds were plentiful. Saw-mills were built along the streams, and lumber was shipped even to the West Indies in exchange for rum, sugar and molasses. The construction of schooners continued until recent times to be an important industry. Now, only small sloops, scows and bateaux are built. Ships of iron, propelled by steam, have superseded the clipper.

---

* It may often be the humblest and least conspicuous plants which yield the richest food materials, and not always the major forest products which, considering labor and time, yield the largest returns. The salep of Turkey and the truffles of France are excellent examples. Salep is a farinaceous food obtained from the tubers of wild orchids. It contains a substance called bassorine, which is very nutritious. Over $3,000,000 worth of truffles are exported annually from France. They come mostly from Perigord, and grow in limestone regions on the roots of oaks.

† Several wild animals have, and perhaps others might be, profitably bred for their pelts. The skunk (*Mephitis mephitica*), one of the commonest and most disagreeable of all the animals of Eastern America, produces a salable fur called "Alaska sable," and in spite of the facts that it emits a nauseating odor and that a kind of hydrophobia results from its bite, has been kept in confinement and bred for its skin. The mink has been tamed and reared in minkeries in New York State. It has been said that a mink is as profitable as a cow. Coues, in his "Fur-bearing Animals of North America," says: "Were not fashion so notoriously capricious, mink pelts would maintain a conspicuous place in the fur-marts of the world; certainly few surpass them in richness of color, gloss and fineness"

Scattered here and there throughout the Pines are the remains of what were once centers of a flourishing industry. This was the manufacture of iron from bog ore (limonite). In some places the furnaces and forges have been completely obliterated and forgotten; in others only bits of black slag remain, while in others the ruins are still standing. These centers of industry, usually located in the neighborhood of streams and bogs, were connected by stage routes, along which here and there were clearings and taverns. Immense quantities of charcoal were consumed by these forges and furnaces, the owners of which usually possessed the land for several miles in every direction. Wood in those days was in demand, and coalings were frequent. Even after the iron industry in the Pines succumbed, charcoal was shipped to the cities by schooners in large quantities. Owing to the abundance of other forms of coal, the demand for charcoal has gradually decreased. Along the rivers there were many depots to which the charcoal was carted, which are still in evidence, owing to the great masses of coal-dust which accumulated there. Coal and iron were worked side by side in the neighboring State of Pennsylvania, transportation by rail increased the competition; the iron industry in the Pines was unable to survive, and with it faded the manufacture of charcoal,* and the value of coal-wood. The ruins of furnaces, the large dilapidated houses, the overgrown roads, the wharves, the piers, the old ship-yards, and the masses of coal-dirt on the landings are evidences of what the country was when iron was made from bog-ore, and when schooners were built to trade to foreign lands. The woods were full of men hewing timbers, cutting coal-wood, working in the coalings, raising bog-ore and carting materials from place to place. The death of these industries, however, is only the result of progress. In the development of the whole of a country, certain parts, although they may have once played an important rôle, must suffer. In the course of its development almost every country is subjected to a series of industrial ups and downs.

Another peculiar old-time industry was the mining of cedar. The bed of a cedar swamp is a mass of forest detritus, several feet in depth, in which there are logs of white-cedar perfectly preserved and excellent in quality. The white-cedar, like the cypress of the South, reaches a ripe old age. Over one thousand annual rings have been counted in buried stumps six feet in diameter, and, judging from fallen trunks, the age of these swamps is many centuries. It establishes the fact beyond a doubt that the white-cedar has been growing in South Jersey for ages, and that it is perfectly at home there in every sense of the word. The wood of many of these buried logs is sound and light. These were dug out, sawn into billets, and split by hand into what were called "mud-shingles," which last for many years.*

---

* It is unfortunate that so little charcoal is used in the American household. The fine flavor of French cookery is partly due to the use of an excellent quality of charcoal. Other kinds of coal and wood emit gases in the process of combustion which taint food more or less, and for successful broiling charcoal and the brazier are necessary.

It seems strange that the mining of cedar, when wood was plentiful, should be more profitable than at present, when white-cedar is scarce and poorer in quality. Lumber is cheaper in parts of Eastern America to-day, however, than it was a quarter of a century ago. This is due to the fact that a much wider field has been brought into competition by the development of railroads, and special long-distance freight rates from regions where timber is still plentiful, and where very complete, labor-saving, wholesale methods of working it are in practice.

The production of tar was not very extensively developed, and lasted only for a short time. The existence of the industry was due to the peculiar exigencies of the times. During the Civil War the North was deprived of necessary naval stores, for which the ship-chandlers were willing to pay enormous prices. The natives of southern New Jersey took advantage of this opportunity and collected large quantities of "fat-pine knots," out of which they manufactured tar.

At one time the splitting of hoop-poles for barrel-hoops was an important industry. Coppice oak was used for the purpose.

---

* In "mining" cedar logs a great deal of skill and experience was required. Of course, many of the trees in the swamp were worthless when they fell. The person in search of shingle logs, therefore, first sounds the swamp-bottom with an iron rod. When he finds a solid log, he notes its position, size and length. With a sharp spade and axe he cuts down to it, in order to secure a chip of it, from which he is able to tell, especially by the smell, whether it was uprooted by the wind or broken off above the ground. In the first case it is apt to be much sounder and better. If satisfactory, he digs a trench along its length, and saws it off at both ends. The hole he has dug soon fills with water, and, after the log has been completely loosened, it rises and floats, being surprisingly buoyant. It turns over also, at the same time, being lighter and fresher in appearance on the underside. It is then rolled out of the bed where it has rested many years, is sawn into proper lengths, and split into shingles. There is still, no doubt, buried cedar in the swamps of South Jersey, but although fine in quality, it requires so much labor to work it that it is no longer profitable.

Owing to the substitution of bags for barrels and iron for wooden hoops, there is practically at present no demand for hoop-poles. At one time many people found employment in gathering the leaves of the upland sumac.* These were ground at the mills and were used for tanning.

The principal industries of the present are the cutting of wood for fuel and the working of timber for constructive purposes. Several minor products of more or less importance are also collected.

Wood for fuel may be divided into two classes—pole-wood and cord-wood. When small-sized trees are cut in the pole stage, such as oak coppice, they are merely stripped of their branches, and are not divided into regular lengths, and are sold as pole-wood, which is consumed locally and bought and sold by the one-horse or two-horse wagon-load. This wood is abundant and has little worth. If killed by fire, as is often the case, it is not seriously injured for fuel, although slightly charred, and often disagreeable to handle. Large quantities of this wood may be had for the asking. The person who sells pole-wood usually receives little more than his labor is worth in cutting and delivering it to the purchaser.

Cord-wood † is cut into sticks four feet long, and split once. It is usually either pure pine or oak, sometimes mixed. If located near a railroad or along a good wagon-road, there is a slight margin of profit in this wood. In many parts of the Coastal Plain of New Jersey it has no worth, because the cost of cutting and transportation is equal to or even more than the market price. Often, however, if the owner has teams of his own, he cuts the wood when slack of other work and transports it in order to furnish himself with labor. His wood-land really has little intrinsic value.[*] It is merely a means to an end. It pays, however, to convert the straight limbs and tops of trees, from which saw-logs have been cut, into cord-wood. South Jersey has to compete in the production of cord-wood with the woodland along the rivers of the neighboring States of Delaware, Maryland and Virginia, where a large negro population exists, which is skillful with the axe and willing to work for small wages.

---

* The chestnut oak (*Quercus prinus*) furnishes the best tanning material of eastern trees. It is hardly safe to recommend the planting of trees for tan-bark owing to the fact that other means of tanning are in process of development, and new and perhaps better methods are liable to replace the old. There are a few people, however, who believe that oak bark will be worth more a few years hence. The use of quebracho, from South America, has had an important effect on this industry, but quebracho wood and hemlock will not last forever. The chestnut-oak is common in South Jersey, and one should have no hesitation in planting it. It grows fairly well in the shade of pine trees. In spite of the use of many other tanning materials, the choicest leather is "oak-tanned."

A cord, in Jersey, is four feet wide, four feet high and eight feet long. It contains eight cord feet or one hundred and twenty-eight cubic feet, or 3.62 cubic meters.

The production of fuel-wood in South Jersey, however, will always take care of itself. Woods should be managed, therefore, with saw-stuff in view. Good lumber[†] is scarce and high in price, while fuel-wood[‡] has practically no value whatever.

Much could be said of chopping in general, and the implements and methods in use of felling and converting trees. The American axe, the most perfect and useful of ordinary implements, is worthy of a chapter in itself. Intelligent chopping should be classed as skilled labor; in fact, by a judicious use of the axe in the hands of a person with an exact knowledge of the conditions which obtain, it is often possible to bring order out of chaos and correct the work of careless slashers.[§]

It requires only a short space to describe the handling of timber in South Jersey. There is no rafting, no skidways, no lumber camps. All this belongs to the past, when ship-building was an important industry. The writer can just remember the long line of mule teams, bound to the shipyards on the shore, with long straight stems of the oak and smooth-bark pine. The logs are now, usually, short and small, the roads are good and level, so that with the help of a couple of skids, cant-hooks and parbuckles the handling of logs is a simple operation.

---

[*] A few years ago wood was sold in Philadelphia from South Jersey for the purpose of dry distillation. There are several establishments of this kind in neighboring States. I fail to see why this industry could not exist in South Jersey as well as elsewhere. It is an industry which would use the rough wood, for which there is no market, and which rots in the forest. There are many dry distillation plants in New York and Pennsylvania, and the demand for the product is constantly on the increase.

[†] The terms "timber" and "lumber" are used in a peculiar way in America. Lumber means sawn stuff in merchantable form. It means also disused articles or discarded goods of any kind, and, according to some authorities, it is a modification of the word Lombard, the Lombards having been, in early times, famous pawnbrokers. Although the word lumber only means sawn or dressed stuff, the term lumberman is applied to a forest proprietor, a lumber merchant, or a worker of timber. Timber is applied to large-sized sawn or dressed stuff, and to the forest of trees large enough to produce such material. Such a forest is designated "standing timber." "Timber-culture" is used instead of silviculture, and the term "stumpage" means standing timber, considered with reference to its value for cutting, so called because the amount cut is ascertained by counting and measuring the stumps.

[‡] A chopper should cut the tree close to the ground, leaving a clean-cut sloping or roof-shaped stump. This lets the water off, prevents decay, and produces a vigorous coppice. The slashings should be piled in open places and burnt where there is no danger of the flames injuring neighboring trees. Always protect the young growth, favor the most useful kinds, and never forget that they are the materials from which the future forest is formed.

[§] It would be difficult to find an apter term for the common run of wood-choppers than "slashers," and the lumbermen themselves have aptly applied the term "slashings" to the immense piles of rubbish which they leave in their wake. It is this slash which brings disaster to the woods because of its great combustibility.

The saw-mills are simple in nature and only work lumber for local demands, finding, however, in the resorts along the shore a good market for building materials.

The income from the gathering of wild fruits is probably equal to, if not more than the yield from fire-wood. The most important of these are the cranberry, huckleberry and blueberry.

The cranberry (*Oxycoccus macrocarpon**) is now extensively cultivated. It keeps well throughout the winter, and forms a rich crimson sauce, which is relished with turkey. Large quantities of these berries are exported to other States, and even to foreign countries.

The high-bush blueberry† (*Vaccinium corymbosum*), which reaches perfection in the swamps of South Jersey, has never been cultivated. It is preferred by many to all other wild fruits. It reaches the dimensions of a large shrub, if not a small tree, on rich, moist, loose soil. The quality of the berries can be easily improved by trimming. The natives know this and accomplish it in a drastic, wholesale fashion by firing the woods. The young shoots which spring up after a fire bear large luscious berries.

The wild grapes are also abundant. The fox grape (*Vitis labrusca*), is plentiful in the swamps, the vines of which often form luxuriant tangles in the tops of the trees. The fruit is dark purple or amber in color, with a tough pulp, but delicious musky aroma, and famous for jelly.

The persimmon tree (*Diospyros virginiana*) bears an abundance of rich fruit. The improvement of this fruit by grafting has begun. At present, when a little green, the fruit is puckery; when ripe, too soft; it is also too small and has too many seeds.

*** The term "cranberry" is properly restricted to the genus Oxycoccus, the term "huckleberry" to the genus Guylussacia, and the term "blueberry" to the genus Vaccinium.**

† White or pink varieties are not uncommon, which are simply cases of albinism. These are very sweet and worthy of propagation.

It contains, however, a larger amount of nutritive matter than other fruits, and is excellent for pies and puddings.*

The beach-plum (*Prunus maritima*) grows in sea-sand, close to the ocean, and in the driest, most inhospitable places, and at the same time bears a large crop of plums, which are excellent in flavor. It is only a shrub, but well worth planting in sandy regions. In addition to the above fruits there are many others of more or less importance for food, flavors and wines.

The floor of a cedar swamp is usually covered with a mass of sphagnum-moss. This is collected, baled in hay presses, and sold to nurserymen for packing purposes. This material is remarkable for its ability to retain moisture and is extensively used in the shipment of plants.

Large quantities of holly, mistletoe, cedar, etc., are sold in the cities. Many thousands of the most beautiful and symmetrical young conifers are sacrificed annually for Christmas trees. If the trees were raised for this purpose it would be a legitimate business, but the Christmas-tree gatherer, in order to secure extra fine specimens, cuts the tops out of large-sized red-cedar trees, just as fishermen peel the inner bark from the butts of the white-cedar for fish-strings.

Many flowers, especially those of Magnolia glauca, are collected in large quantities and sold.

The cultivation of the willow for basket work is in its infancy in New Jersey. The wood of the white-oak (*Q. alba*), when split into thin slivers, is an excellent basket material.† These baskets are strong and durable. The common American market-basket is not woven. It is extremely cheap and simple, and goes with the contents.

There are many plants of more or less value medicinally. Perhaps the most important, which is common throughout the woods of the E. Carolinian Zone, but rare in New Jersey, is the witch-hazel (*Hamamelis virginiana*), a fluid extract of the twigs, etc., of this plant is a famous lotion for allaying inflammations. It is used by everybody for the ills of both man and beast. It is a peculiar shrub, with several branching crooked trunks, about ten feet in height. Its pale yellow flowers bloom late in autumn when the leaves are falling, and the woody capsule, which explodes and scatters its two black shining seeds, matures the following summer. It grows well on the poorest kind of gravelly soil.

---

* The persimmon grows luxuriantly in the old fields of South Jersey, where animals have carried the seeds. It is possible to bud or graft these trees with choice varieties of the persimmon, which produce, when in the proper stage of ripeness, a very delicious and salable fruit.

† The basket-tree of the South, however, is *Quercus michauxii*, the basket or swamp-white-oak. This tree is very closely related to *Quercus platanoides*, if not a southern form of the same. It grows in the swamps of South Jersey, but is not abundant. It is one of the most magnificent trees of the oak family. A few years ago it was plentiful on rich southern swamp bottoms. Its wood is of very fine quality for constructive purposes, and possesses a peculiarity which especially fits it for basketry. Each annual ring may be easily separated in the form of a thin flexible strip of great pliability and strength. The thousands of baskets used in the cotton fields of the South were woven from ribbons of this wood. This, together with the facts that it requires rich land, and does not reproduce itself freely, is about to cause its extermination.

Acorns are abundant and are fed to swine. There is a fair crop almost every year, and an immense crop every now and then. Turkeys which thrive on dry, sandy soil, feed on the acorns. Black walnuts contain rich food material and are used by confectioners. Hazel-nuts grow well in the swamps, having escaped in several places from cultivation. The wild chestnut thrives in the moist sand of South Jersey, and although the nuts are usually small, they are very sweet and abundant. In addition, the collection and careful preparation of the seeds of important forest trees would yield ever-increasing returns.

I have yet to mention forest litter, especially the collection of "pine-chats" * or leaves, which in many pine regions plays a very important and peculiar role.

Forest litter is extensively collected in southern New Jersey for the bedding of animals and as fertilizer for sweet potatoes ;† in fact, fair crops of this staple food material may be raised on extremely sandy soil, without other manure.

It is, however, south of New Jersey, on the peninsula between the Chesapeake and Delaware, where the litter is most assiduously collected and used. The conditions which exist there are peculiar and instructive to those interested in the amelioration of pine-lands. In fact, it is the demand for forest litter which in a great measure has prevented forest fires and impressed upon the natives the value of their forests.

---

* In provincial English the term "chat" means catkin, or a twig for kindling. The term "catkin" means little cat. There may be some connection between the old English application of the term to small twigs and the use of the word pine-chat in the South.

† The German literature on this subject is quite exhaustive. The manurial value of pine straw lies mainly in its nitrogen contents. From one acre there may be had annually about 2,500 pounds of straw, furnishing about 20 pounds of nitrogen, 12 pounds lime, 3½ pounds potash, 3¼ pounds magnesia and less than 3 pounds phosphoric acid.

Almost every farm has its pine forest. These, of course, are of all sizes and ages, varying from fields as thick and dense as grain to forests fit for large-size timber. There are few signs of forest fires.

The soil is light and sandy, dune-like in nature, along the shore, to which the pines grow close, although a few have been killed here and there by shifting sand. The natives recognize the value of the forest in holding the soil in place, and in protecting their truck-patches from the force of the wind, which would naturally at times sweep over this narrow peninsula.

On entering one of these forests, one observes at once that although there are many small trees of holly, and bushes of sweet-gale, the ground is free, from litter and brush. If one happens to visit the region at the proper season he will see men and women raking up the forest litter. Very early in the spring or late in winter one can see field after field covered with pine-chats, to be plowed under just as soon as the weather permits. In fact, the fields are laid out in squares, by means of the plow, in order that the pine-chats may be easily measured and thus evenly distributed. Just as soon as a field becomes worn out it is abandoned; the adjoining woods furnish the seed, the wind sows it, and soon a fresh growth of pines appears. Here and there throughout the forests there are avenues, which, although constructed to facilitate the collection of pine-chats, serve at the same time the purpose of fire-lanes.

Because of the value of the pine-chats the forest floor is free from inflammable materials just at a time when fires are most likely to occur. The removal of this debris is contrary to the principles of German forest management, because it naturally impoverishes the forest soil. In the course of time, however, many of these potato-fields are allowed to come up in pines, and fresh fields are cleared when the pines have been cut.*

---

* Unlike other crops, the forest constantly improves the soil, providsd the litter is not removed or allowed to burn. The roots of trees penetrate to its deeper layers, and absorb large quantities of mineral matters. A large percentage of this material goes to the leaves, and is deposited on the surface. The surface soil is both enriched by these mineral substances and protected by a mulch of humus in varying stages of decomposition. As the lower layers rot, new layers of leaves and twigs are being constantly deposited, so that the forest soil, in the course of time, fairly reeks with nourishing plant-food. It has been shown, without doubt, that the removal of litter from poor soils is ruinous. It is like stealing food from a starving man. The removal of forest litter from rich soils is indeed, however, a very small matter, and it is doubtful if it really does very serious injury.

Another point of great advantage is, that the forest is not continuous, but cut into parcels, with farm lands and glades intervening. In fact it is a land of thrifty forests without foresters, and practically without the need of forest laws.

For private holdings of pine lands, I am inclined to favor this method of management, under the peculiar conditions existing in certain parts of America. In this way the forest constantly yields, indirectly, an important income. It is simply a rotation of crops, of which the pine is the most important, producing throughout its whole life a material which, to the farmer of the eastern shore of Virginia, is of more value than wood.*

It is easily seen, from the condition of the forest industries which have just been described, that the Coastal Plain of New Jersey has passed through the first and most lucrative stage of its existence. The time is at hand for the establishment of industries with permanency in view. The most important step in the right direction would be the protection of its woodlands, game, fish, oysters and clams, which were once so abundant.

---

* By this system of culture the pine naturally and quickly regenerates. Large quantities of swine run in the forest in this region, and probably do as much good as damage in keeping the soil loose on the surface and by covering the seeds in the process of rooting.

II. Forest Policy and Silvicultural Suggestions.

FOREST POLICY.

As has been explained already, there exists in Southern New Jersey a vast area of land which is in a deplorably unproductive state. It is sufficient to say that in the hands of private owners, under the circumstances which at present exist, the future of a large part of this land is not bright. A change of some kind is necessary, and this must come either in the form of a change of ownership or of the circumstances which fetter ownership.

The only way in which the ownership may be quickly and materially changed would be by State purchase. It is questionable whether under the circumstances State ownership would be justifiable, and whether, even if it could be easily accomplished, it would improve the situation. The State ownership of forest land in New Jersey is only justifiable on the ground that the presence of forests is necessary for purposes of protection against the destructive forces of nature, for pleasure parks or for the purpose of preserving the beauty of certain unusually beautiful or wonderful localities, such as the Palisades.

It is generally conceded in this country that State ownership of forest land for revenue is unnecessary. The American people, in fact the Anglo-Saxon race as a whole, has a wholesome aversion to the participation of the State in industries for the purpose of revenue.

Many claim that even in cases where the forest exerts no very marked influence in a protective way against the destructive forces of nature, that the State ownership of forests is justifiable on the grounds that it requires so long for trees to mature that private individuals are unable to grow and handle them satisfactorily to themselves or to their neighbors.

This argument, however, does not always hold good. Were a man to plant the seed and then wait for the forest to mature, even the most ardent forester would become impatient. Were he to begin, however, with a forest such as exists even in New Jersey, he could, even from the beginning, reap something every year, and his forest would, at the same time, improve in quality and productiveness. It is quite possible for a private individual to sow the seed and reap at least three or even four crops of salable materials in a lifetime. It is worthy of note that some of the finest, that is the most productive, forests of Denmark are under private control. A private forest does not always mean a neglected forest and a short rotation. Many rich families in Europe gladly avail themselves of this sure and permanent way of investing their fortunes, which pass from father to son, as do the date-groves of the East. In America the railroads, express, telegraph and telephone are private. The finest institutions in America are due to private enterprise. Great public reforms are usually brought about by the energy and influence of a few public-spirited people. After all, what is the state in America? It is simply an organized community, the ruling powers of which are only persons which the people have chosen temporarily from their midst. The purchase of forest land, the management of forest land, or the sale of forest land, depends upon what the majority of legislators may think best, and they in turn are supposed to comply with the wishes of the majority of their constituents. The personnel of the legislature is constantly changing, so that the management of forest lands owned by the state would be subject to many vicissitudes unless placed permanently and absolutely under the care of one of our best educational institutions or in the hands of other permanent and reliable trustees. Since, then, the state control of forest lands is not justifiable on the grounds that large timber cannot be raised from the seed in an ordinary lifetime, let us consider briefly the question of protection which it affords in South Jersey against the destructive forces of nature.

The effect of the forest on the climate of South Jersey, except in so far as it breaks the force of the wind, is probably slight. Owing to its insular position the effect on the precipitation of moisture is probably not considerable. The effect of the forest in these respects is in general disputed and not proven. The effects of the forest on the run-off of water is also of small moment because the country is so flat and the soil is so porous that floods never have and probably never will occur.

The great function of the forest on the sandy soils of Southern New Jersey is the beneficial influence which it exerts on the quality of the soil, both physically and chemically. The forest fixes the soil, preventing it from shifting. The winds would blow it from place to place were it absolutely bare. The forest brings from the subsoils inorganic materials which it deposits on the surface in the leaves and wood. The soil is enriched and protected from the beating and leaching force of the rain and the drying effects of both sun and wind. The granules of silica are gradually comminuted by the chemical action of decomposing organic matter so that the influence of the forest on a coarse, sandy soil tends to render it more and more of the nature of loam, and finally, in the course of ages, fertile and able to support not only a dense forest growth, such as Fontainbleau, but even in time fit it for agricultural purposes. In fact, this is the only rational form of treatment for such soils, and although they may become fit for agricultural purposes in the course of time, the forest should be one of a series of crops. In this system of rotation the interval from the time the forest is cut until the land is allowed to come again in forest should be short.

In rocky regions the soil is constantly fed by disintegrating stones on the surface and in time recuperates, but with sandy soil the only natural fertilization is by means of the forest, which returns, in part at least, the materials which have leached into the deeper layers of the soil while the land was under cultivation.

Since, then, considering all things, the State is not justified in purchasing and managing these pine lands, and since it is extremely doubtful whether their condition would be materially changed by State ownership, it is important to consider the circumstances which fetter private ownership. It is safe to assume, without further discussion, that the woods of South Jersey, for a long time to come at least, are destined to remain in the hands of private parties. They must be regarded, therefore, as *business* and not *protective* forests, although they may of course perform both functions at the same time. The possibilities of successful forest management from a business standpoint are dependent upon certain fundamental conditions. These forests must be regarded in the light of *supply forests* for materials needed for local consumption and for export to neighboring cities. We must consider, therefore, the following conditions:

(1) The ability of the State to afford protection to private property.

(2) The geographic position of the region in reference to markets and in reference to means of transportation.

(3) The value of land and the cost of labor.

(4) The quantity and quality of the materials the region is capable of producing.

(5) The ability to use the materials in local industries.

(6) Fair taxation.

Let us consider, first, fire:

This is the kernel of the whole question. Although no end of legislation has been passed on the subject, nothing has been accomplished. Not to mention forest management, the State has failed up to the present time to protect the property of its citizens. Until this is accomplished but little progress is possible.

The "fire season" in New Jersey begins about the middle of March, and continues with more or less fierceness until the end of October. Sometimes only the thin leaf-covering of the soil is burnt, and little damage is done; sometimes the deep, dry muck of the swamps burns for many days, and sometimes the fire sweeps through the crowns, but often the surface, crown and ground fires are one, roaring and rushing irresistibly with the wind, with miles of front, until stopped by a lack of food material, a fall of rain or a stream of considerable dimensions.

About fifty per cent. of the fires of the Coastal Plain of New Jersey are caused by sparks from locomotives, ten per cent. are set by incendiaries for evil purposes, ten per cent. are set purposely to improve the berry crop or pasturage, and the rest are accidentally and carelessly set.

The effects of fire are practically the same all over the world: impoverishment of soil, destruction of game and its food supply, unhealthfulness, increase of insect pests, in addition to the loss of wood and other property and injuries to industries which use wood.

For the prevention of fire, the punishment of fire-setters and the construction of wide fire-lanes along all public wagon-roads and railroads, are necessary. Railroad companies should be required to construct lanes, broad and clean enough along their tracks, to eliminate all danger from flying sparks, to ditch all swamp-lands to water or sand on the outer edge of the lane, and to constantly use efficient spark-arresters on their engines. The townships should be required to construct similar lanes along all public roads. In this way, what are now points of danger, from which the majority of fires start, would become avenues for the prevention of its spread, and would serve at the same time as vantage points in combatting it. Whenever possible these fire-lanes should be kept under cultivation, in other places the brush * should be cut, and all combustible materials burned at a time when there is no danger of setting fire to the adjoining woods. The usual method of extinguishing extensive fires is by "back-firing" or "counter-firing." This is, however, dangerous work, and should not be attempted save by those who are experienced and capable. Very often the back-fires, set by inexperienced, excited persons, have not only resulted in disastrous conflagrations, but have rendered the skillful work of others of no avail. For the extinguishment of surface-fires, shovels, sand and hard work are usually sufficient. Fortunately, sand is everywhere plentiful, except in swamps. It is often possible to beat out surface-fires with a green bough or bush. In the extinguishment of ground-fires, or those which burn in the peat of swamps, it is necessary to confine them within certain limits by digging deep trenches.

Formerly charcoal burners set fire to the forest in order to be able to purchase it cheaply, by rendering it unfit for any other purpose than coal wood. The charcoal industry is done, but the natives still fire the huckleberry-bush to produce fresh shoots on which the finer berries grow. Berry-picking is an important industry, and the occurrence of such fires is common. The main differences between the conditions existing in Southern New Jersey and the peninsula between the Chesapeake and the Dela-

---

* The "Esterel," a region of France not far from Cannes, is famous for the elaborate fire measures which are in force there. It is a mountainous district, thinly covered with pine and cork-oak and extremely susceptible to fire, which causes great havoc when the very violent wind, called mistral, blows. I visited it a few years ago and was surprised to find that, in addition to the formation of many fire-lanes, the removal of underbrush, observation posts, telephone, perfectly organized patrols, etc., that they burn over patches of the surface every year from December to February with the object of preventing the growth of weeds and underbrush and the accumulation of combustible litter. Little by little the whole area is burned over in this way.

ware are, that the forest-land there is cut into many small blocks, between which is farm-land, and that the proper sentiment exists in the minds of the natives, a sentiment due to the value of the pine-chats.

The division of large tracts of land into parcels is of advantage economically and socially, provided they are of a size sufficient to support a family of ordinary intelligence. Such a farm should consist of at least thirty-five acres of cleared land and sixty-five acres of woodland. The sale of city lots in the woods, or even five or ten-acre plots, is rarely fruitful of good, and is, on the whole, detrimental in the end to the purchaser and community in general.

Where fire constantly burns the litter from the surface and prevents the formation of young forests, the soil constantly deteriorates and finally becomes sterile and lifeless—literally lifeless—because the organisms in the soil which cause the decomposition of humus and the conservation of nitrogen are killed. The prevention of fire, therefore, is of course the first and most important step.

Further discussion in reference to the prevention of fire on lands owned by private parties seems like threshing old straw, but since it is hardly likely under the circumstances that the State would buy and properly care for this vast tract of sandy land, or would force private parties to institute efficient measures in this line, as is common in Europe, it is necessary to devise other schemes which might accomplish this end and which fit the peculiar conditions, political, social and economical, which exist.

It is generally recognized throughout Europe that the construction of suitable fire-lanes throughout the forest conduces more to the prevention of great conflagrations than any other institution. The recent fires in the Landes of France were due, it is claimed, to the neglect of fire-lanes. These serve as vantage points in the fighting of fire, and often in themselves are sufficient to prevent its spread. By means of fire-lanes the country is cut into parcels and the danger of great conflagrations very materially reduced. These fire-lanes, in order to be efficient, must be wide, clean and well cared for, for otherwise they are of little use. Now the great question is, how to establish a complete system of fire-lanes for those regions of Southern New Jersey which, from the sandy nature of their soils, are destined for many years to come to remain in forest.

The scheme which I have to suggest is that these fire-lanes be constructed and kept in order in a way similar to the construction of State roads, which have been so popular of late. In this way no terrible burden of expense rests upon anybody. The individual benefited thereby pays part, the community pays another part and the State pays the other part. Woodland owners who would be benefited thereby would not hesitate to donate land for the purpose, while the small quantity of land required of those who may be foolish enough to object should be summarily condemned and appropriated by the State. One would expect very slight opposition to a system of fire-lanes from those persons whom the protection it affords benefits, except perhaps from those who call themselves "land-poor," that is, persons who own so much unproductive land that they cannot pay their taxes.* Such people would not object to the relinquishment of small strips of unproductive land, but would hesitate with the fear that it might increase their burden of taxation. But the difficulties of this kind would be no greater than those which have been met and overcome in the construction of roads. As with all progressive movements of this kind the opposition fades away and the strongest opponents are often the loudest of praisers in the end.

The owner of the land would be benefited and encouraged and the payment of a slight increase in tax would be a great and permanent investment. Lands which are now a burden to him would become more valuable and the capital which is buried therein would increase and, if need be, become available. The money which the county and State would expend would return a hundred fold in increased resources and prosperity, and would benefit those who are most in need of it.

The State or county or township ownership, or combined ownership, of a system of fire-lanes, in no way savors of paternalism, and should be as palatable to the American taste as the

---

* Fire-lanes may be constructed at slight expense in Southern New Jersey. After the wood is cut it is necessary to plough three or four furrows along the edges and then to burn over the lane at times when there is no danger of setting fire to the neighboring woods. A lane fifty feet in width would be quite efficient.

State ownership of roads. In fact these lanes may serve at any time as roads, or may be converted into such on short notice at almost any time. Fortunately gravel is almost always near at hand, so that in the course of time the whole fire-lane system may be converted into a great road system, which would add much to the value of the land and increase the value of the wood, owing to the ease with which it could be transported. After visiting most of the forests on sandy soil in Europe, and having lived a number of years in the pine-lands of South Jersey, I am convinced that it is foolish to talk of forest culture and silvicultural methods until fires are reduced in number. For this purpose fire-lanes are essential, and this is the only scheme I know of which seems practical and possible. Once institute a perfect system of fire-lanes under combined State and local control and the number and severity of the fires will be reduced to such an extent that the evil will, I am certain, gradually fade away, and modern systems of silviculture will gradually creep in as the value of wood and land increases. The people of the State are perfectly familiar with the modus operandi of the road law, and the same general principles applied to fire-lanes would be no great and startling innovation, but would, I am certain, be fraught with beneficial results. It is the only system which appears to be perfectly adapted to the peculiar conditions which exist in Southern New Jersey.

Such an institution would have also a great educational effect. Many people who had never thought of such things before would be impressed by the object-lesson. The constant presence of such reminders would impress upon certain classes of people the facts that fires are not necessary, that the useless destruction of wood is wasteful, and that the absence of wood in a country which is fitted only for its production means a lack of work for woodsmen, teams and sawmills.

In addition to these fire-lanes let all the existing roads of the southern part of the State become a part of this system by being converted into fire-lanes, that is, widened and cleared of combustible materials along their edges. The remotest portions of these vast piney-lands will in this way become accessible, and the large amount which is actually invested in woodland and cranberry-bogs will be rendered safer, with surer yields. A large amount of money which is lost in fire-fighting will be saved.

Just as there was opposition in the beginning to the new road law, so there will be opposition to such a scheme; but let the State inaugurate it in a trial district and soon others will follow. It will not, of course, stop all forest fires, but it will certainly reduce their size, stop their fury and save the loss of much valuable material. The new State road from Atlantic City to Camden is a fair sample of what is needed. It serves at the same time the purpose of fire-lane and thoroughfare. Formerly it was a bed of hot, dusty sand. Many new buildings have been constructed along the road, and owing to the ease of communication and transportation it has brought the people along it closer together and has instilled into the old residents a certain amount of life and spirit which they never would otherwise have obtained. If cleared of brush along their sides, many of the gravel roads of South Jersey, which are often now the points from which fires start, would serve as fire-lanes in preventing the spread of fire and as vantage grounds in combatting it. The local officials who have charge of these roads and lanes could, if required, extinguish many fires in their incipient stages.

The consideration of these fire-lanes as future roads leads to the second important condition—markets and transportation.

This question needs but little consideration. A glance at the map is sufficient to convince anyone that no region could be more auspiciously located in this respect. With plenty of good gravel with which to construct roads, with many railroads, with many navigable rivers and with two of the largest cities of this country near at hand, but little more in this respect could be desired. At the same time, however, we must not fail to consider the fact that other great wood-producing regions are near at hand and that in Pennsylvania there are immense quantities of coal. This state of affairs naturally suggests that the production of wood for fuel, as is now generally the case, is the least profitable of the forest industries which may be practised in South Jersey.

The third condition relates to land and labor. This question also needs little consideration. There are thousands of acres which may be had at a ridicuously low figure, considering the location, and everyone familiar with the region knows that there are hundreds of woodsmen who are stagnating and degenerating in consequence of a lack of work.

The fourth condition relates to the quantity and quality of the materials the region is capable of producing, and since I shall refer to this later under the head of Silvicultural Suggestions, it is sufficient to say in this connection that owing to its peculiar soil and climate South Jersey has and is still able to produce just those kinds of forest produce which are most in demand.

The fifth condition relates to the possibility of the establishment of local industries which may consume the products of the forest or which may convert these products into less bulky and more salable form.

When certain industries may be established within a region it is, of course, a great advantage in many ways. It increases the working population, the value of property and improves the standard of life. Labor is at the base of pleasure and intellectual development.

At present large quantities of wood are supplied to glass and brick factories throughout South Jersey. The fuel question, however, is of little importance, and will always take care of itself in this country. In fact, even the woodsman, when he can afford it, will burn coal because of its convenience.

The first industry which would flourish on the production of saw-stuff would be the saw-mill. And if only the increment is cut, as should always be the case, many small mills, instead of a few large ones, would result. The condition might be similar to that of parts of Germany where many small mills are constantly at work year after year cutting the well-earned increment. The big mill with its elaborate, costly equipment, working with feverish excitement half the time and idle the rest, did not develop however in this country until after the timber resources of South Jersey were practically exhausted. Even in the great lumber districts the large mill, when our lumber resources have been exhausted to such an extent that these voracious monsters cannot be fed, will be replaced by smaller establishments which will for some time to come operate on the leavings and the young timber as rapidly as it becomes merchantable. The time is not far distant when the great lumber industry which has shot across this country with meteoric fierceness will have spent its power. It has been digging its own grave. In the meantime the tide of feeling in reference to the establishment of more rational methods of forest treatment has been steadily rising. This country, although so large, is so closely knitted together by a network of railroads, which favor the distant parts by special long-distance freight rates, that a stringency of even so important and bulky an article as lumber will not be seriously felt until the crop is exhausted, even in the remotest corners of this land, if not this continent. There is nothing surprising in the fact that a man in New Jersey may use in the construction of his house white-pine from the far North, cypress and yellow-pine from the far South and redwood shingles from the far West, and buy it all from the stock of one lumber dealer in Philadelphia or New York.

Besides the development of the saw-mill industry in Southern Jersey, when the woods are properly protected and managed there will arise, no doubt, many other industries, such as box, stave and market-basket manufacture.

It is, of course, impossible to predict the many industries which may be operated in a country where such a useful material as even the poorest grade of wood is produced.

In the Spessart, in Germany, for instance, years ago immense quantities of beech were planted, to supply the glass factories with fuel. The glass works have ceased to exist and the beech is subjected to a process of dry distillation which yields several valuable products. Hardwoods, by this process, will yield charcoal, pyroligneous acid, an inflammable gas which may be used for illuminating purposes, besides other products. Some day we may export charcoal to the tropical regions of the globe, where it is the most satisfactory fuel because it emits no smoke, and braziers can be used instead of stoves.

Then there is the possibility of producing wood for pulp and cellulose. Spruce is the principal source of supply at present, but even if spruce cannot be produced successfully in South Jersey, which is, however, a question, there are other trees which are and no doubt many which may be used for that purpose. In fact it would be impossible to predict the future of this industry, which, although in its infancy, is already immense.

It is safe to assume that in case the forests of South Jersey are protected and allowed to grow other industries will form and grow with them.

The sixth condition is fair taxation. All are agreed that this is a knotty question and one difficult even under favorable circumstances to fairly adjust. It seems to me that since forests require considerable time to grow, since owing to the force of the elements and disease the growth of years is liable to be suddenly spoiled and shattered, since forests are not insurable, and since the man who produces a forest is the benefactor of his neighbors, the State can well afford to tax lightly such land.* In fact, the man who starts and properly cares for a forest deserves to be exempted from taxation, or at least exempted until the crop is cut. Several have suggested that the tax should be levied only on the amount cut. This plan, of course, has some disadvantages, and may not be practical. At any rate a fair re-adjustment would tend to improve the condition which exists. I have faith enough in the good sense of the American people to believe that with proper protection by the State against fire and thieves, with fair taxation, with sufficient roads and with proper guidance, there will develop even under private control a system of forestry which, although perhaps not as systematically regulated as in Europe, will be as good as the peculiar economic conditions of the region will warrant.

SILVICULTURAL SUGGESTIONS.

It seems to the writer that, notwithstanding the complexities of European silvicultural systems with their manifold modifications and combinations, the methods of forest treatment may be divided into four systems which are more or less applicable the world over, none of which are unconditionally good or bad, and the merits of which depend upon the circumstances of each case. Each system has its advantages and disadvantages, and must be adapted to the conditions which exist in every instance, and its success, above all, is dependent upon the knowledge and skill of the person who endeavors to apply it. These systems are, briefly, as follows:

---

* An anomolous condition sometimes exists where a speculator desires a high assessment and correspondingly high tax in order to convince prospective buyers of the great worth of the land which he is endeavoring to sell.

I. The selection system, which is especially adapted to uneven-aged or irregular protection forests.

II. The system of clear cutting and then regenerating by planting with young trees or by sowing the seed, or by waiting until the wind sows it from an adjoining forest.

III. The system of regenerating pure even-aged forests naturally by uniformly and gradually thinning throughout, and admitting the light so that the seeds will germinate and the young growth properly develop.*

IV. The coppice system, where the forest consists of species which will sprout from the stump or the root.

There will probably be opportunity for the application of all of these systems in Southern Jersey. The following is a brief way of classifying these systems:

Selective-cutting system, applicable to pure or mixed forests of uneven age.	Regeneration effected irregularly throughout the forest by the removal of single trees or small groups of trees.
Clear-cutting system, applicable to pure or mixed forests of even or uneven age.	Regeneration by means of planting young plants or cuttings or by sowing by hand or by natural sowing from adjoining woods
Successive-cutting system, applicable to pure woods of even age	Regeneration effected uniformly throughout the forest by successive thinnings and final complete removal of mother trees.
Coppice system.	Regeneration effected by stump-shoots and root suckers.

If a party possesses woodland, even if sparsely stocked with inferior kinds, and cannot afford or may not desire to plant afresh with better species, but wishes to gradually improve it, the best system to apply is the selection method.† There are many large forest-owners in South Jersey who are able to employ a forester but who cannot afford the cost of extensive plantings. These large land-holders employ managers who are practical men but with little knowledge of forestry. The selection method is usually the best for a new country where the demands for wood are less than the supply, and where a system to be popular must yield enough constantly to pay all expenses, taxes, and a little besides. It is an excellent system for co-operative associations and corporations which have other objects in view, such as the protection of game or water supply. It is extensively practiced in India, where it is usually known by its French name, "jardinage." It is not confined to new countries, however, and is even the favorite method of many European foresters of treating protection forests.

---

*As early as 1736 this system had developed so far in Germany that three distinct cuttings were prescribed: First, when the seed had fallen and germinated; second, when the young trees reached the height of a man's knees, and third, the mother trees were completely removed when the young trees had reached the height of a man.

† Irregular forests to which this system is applied naturally suffer more from fire than regular forests.

To apply this system it requires more skill, experience and intelligence than the majority of land-holders or managers possess. It is, however, an elastic system, and in its simplest form is practical for land on which there is any growth worthy of the name of forest.

It is about the reverse of what is ordinarily practiced in America. In New Jersey one man may buy all the merchantable oak on a certain piece of land, another all the cedar, etc. Any diseased trees or kinds without value are left standing, not for soil protection, but because they are not worth cutting. These are stimulated by the increase of space and light, produce large quantities of seed, and soon have complete possession of the soil. In other instances the land is bought with all that covers it and stripped of what is merchantable. Covered with slashings,* it is left to be swept by fire or abandoned to the weeds,† or is sold to land-agents who divide it into many small farms, which they sell to all sorts of new-comers. Sometimes it falls into the hands of speculators, who hold it indefinitely, with various purposes in view. In consequence of this mode of treatment, uplands which once produced pine fit for ship timbers are now only bush-lands; swamp-lands which have yielded choice white-cedar are now cripples. The only suggestion of silviculture is the custom of leaving a seed-tree here and there. Many of these seed-trees were left, however, not for the purpose of seeding the ground, but as line-trees, to mark the borders of properties.

---

* The first steps toward forestry in Germany were the removal of slash and the leaving of seed-trees here and there of a desirable species.

† A weed is simply a plant out of place. Trees, under certain circumstances, may be weeds. In fact, the common custom of culling the best from the forest is similar in effect to harvesting the vegetables and fruits of a garden without disturbing the weeds.

In the swamps of South Jersey, clambering vines and worthless briars and bushes often have complete possession of the soil. The various species of grape which mingle with the branches of trees hinder, of course, their growth, but, owing to their beauty and the value of their fruit, their presence is not so odious. It is quite otherwise with the poison ivy (*Rhus toxicodendron*) which firmly clasps the roots, trunks and branches of trees, and is poisonous to the touch. The swamp sumac (*Rhus venenata*), which is a shrub, and often almost a tree, is abundant, and is also poisonous, causing a distressing dermititis, which is often accompanied by serious illness. Another class of extremely disagreeable weeds are the climbing, prickly briars of the genus Smilax. The most provoking feature of these weeds is that when their rhizomes have once gained possession of the soil, it is well-nigh impossible to eradicate them. Clothing and skin are torn in handling them, burning only causes them to sprout with fresh vigor, and, if left alone, they soon reach the tops of trees, to which they become inextricably attached. The only way to get rid of them is to cut them down with a bush-hook or machete, and then with a grub-hoe dig up heir rhizomes, bit by bit and year after year, until their extermination is complete.

The aim of the selection method is the constant betterment of soil and forest. It prescribes that the soil must be kept covered, and that the most valuable species must always be encouraged. The dead and diseased trees must be removed, also all inferior kinds which are a hindrance to a young, more promising growth. Many minor points the owner or person in charge must settle. The axe must be cautiously used, and always with a purpose beyond the immediate reaping of a wood crop, and the operator must be perfectly familiar with the peculiarities of the species with which he is dealing. Caution in cutting, and the sowing of seed, or the planting here and there of desirable kinds, will, in the course of time, bring order out of chaos.

On large areas of Southern New Jersey where there is little more than bushes it will be necessary to plant afresh. In many instances where the forest is very thin and of poor species it will pay in the end to cut clean and establish a new forest by either planting or sowing. The system of clean cutting and planting has many advantages and disadvantages. One can work in a systematic and regular manner and can start the kind of forest he prefers. It is, however, usually expensive, the young plants are in greater danger of frost, drought, weeds and disease, and the fertility of the soil is impaired by being bared to the action of the elements for a considerable period of time.

If one has a pure, even-aged forest, the third system is probably the best. This is the system which is so successfully applied to the spruce forests of Europe, and is an excellent way of regenerating white-pine in this country, and also, perhaps, white-cedar in South Jersey. In this system regeneration occurs uniformly over the whole area under treatment. When the trees have reached maturity regeneration is effected by a series of uniform successive thinnings. The number of thinnings depends upon the circumstances of the case. Success in the method depends primarily upon two conditions: First, the trees must be in condition to produce a good crop of seeds; and, second, the forest floor must be a favorable bed for germination. From that time on the forest must be gradually thinned and finally removed as rapidly as the condition of the young growth will permit, which varies with the species, climate, soil, etc.

This system is only applicable to pure, even-aged forests. This is a disadvantage, however, because for several reasons the tendency at present is decidedly in favor of mixed growths. Pure growths, especially of conifers, are much more seriously injured by the destructive forces of nature, such as winds and insects, than mixed forests. An excellent form of forest from a silvicultural standpoint consists of a growth of conifers with an underwood of some kind of shade-enduring deciduous trees. The overwood is healthier and the soil is protected and enriched by the underwood. To produce this kind of wood it is necessary usually to resort to the clean-cutting system with regeneration by planting or sowing.

The fourth system, coppice, is so simple that little explanation is necessary. The crop is simply cut clean year after year, and the new crop is formed either from stump-shoots or root-suckers. Care should always be exercised in cutting the stump close to the ground, with a clean sloping top, so that there will not be the slightest opportunity for rot and so that the young shoots will be healthy and sound.

In the choice of species for planting and for favoring in mixed growth we should not fail always to consider the silvicultural qualities as well as usefulness for lumber. Fashion often guides us in our choice of kinds, and we should not fail to bear in mind that modern devices of treating wood may completely change its appearance and durability.

The species of trees which may be successfully grown in southern New Jersey I have divided into two groups—first, those which require good soils, and, second, those which will thrive on the poor sandy soils and swamp-lands of the Coastal Plain; and since the latter are the lands to which the forest will in time be relegated, I shall describe here mainly those species of the second class.

To the first class belong such trees as the white-pine, the white-oak, the swamp-white-oak (*Quercus platanoides*), the beech, the chestnut (*Castanea dentata*),* the black-walnut, the shagbark-hickory, the tulip tree, the white-ash, the sugar-maple, the basswood, the Douglas-spruce (*Pseudotsuga taxifolia*), and the Norway-spruce (*Picea excelsa*). To the second class belong such as the following: the short-leaf-pine (*Pinus echinata*), the red-cedar (*Juniperus virginiana*), the white-cedar (*Chamæcyparis thyoides*), the locust (*Robinia pseudacacia*), the cottonwood (*Populus deltoides*), etc.

Others which may be classed as subsidiary sorts, and which, under certain circumstances, are worthy of encouragement, are chestnut-oak (*Quercus prinus*), sassafras, holly (*Ilex opaca*), bilsted (*Liquidamber styraciflua*), brewster (*Magnolia glauca*), red-maple (*Acer rubrum*), and wild-cherry (*Prunus serotina*).

Pinus echinata, formerly *P. mitis*, is the most important pine of Southern New Jersey. It is usually associated with the pitch-pine (*Pinus rigida*), with here and there patches of the scrub-pine (*Pinus virginiana* or *inops*).

Several foresters have encouraged the planting of pitch-pine in New Jersey, because it grows on extremely poor soil, and endures a great deal of fire. This tree is not the equal of *Pinus virginiana* and inferior in almost every respect to *Pinus echinata.* It is a mistake to encourage the propagation of inferior species, such as the pitch-pine, in regions where *P. echinata* and several other excellent trees grow equally as well. Pitch-pines are, of course, better than nothing, but when they are mixed with *P. echinata*, as is often the case in Southern New Jersey, the latter should be favored. In spite of fires, and the great demand for its wood in early times for ship construction, owing to its marvelous reproductive ability, the smooth-bark-pine has held its own.

*** In a way, the chestnut is without a rival. It is a rapid grower, forming a vigorous coppice, producing a valuable nut, and yielding a wood which is highly prized for fuel, fence-posts, fence-rails, ties, telegraph poles and interior house-finish. For the latter purpose it has become of late very fashionable and is equal in beauty to other hard woods which are worked with much more difficulty. The chestnut should be grown wherever the soil is able to support it. Like the black-walnut the chestnut is able to grow on soils which may be classed as medium in quality, and (in places where there is sufficient moisture) even on very sandy soil.**

In the "Timber Pines of the South," Dr. Chas. Mohr, in the chapter on this species, says: "When maintenance of forest, and production of timber under a rational system of forestry is to become the rule, this species, above all others of southerly distribution, will claim attention, for it can be safely asserted that of the coniferous trees adapted to the climatic conditions of the Southern Atlantic forest, no other can be found of better promise, for the production of valuable timber in the shortest time." In another place he says: "Among the coniferous trees of Eastern North America, the short-leaf-pine stands next to the long-leaf-pine (*P. palustris*), in importance to the lumber industry and in the value of its timber. Freer from resinous matter, softer, more easily worked, not less susceptible of a good finish, the lumber of the short-leaf-pine is often preferred by the cabinet-maker and the house-carpenter to that of the long-leaf-pine. Less tenacious and of less power of resistance under strain, it is principally used for the lighter frame-work in buildings, for weather-boarding, flooring, ceiling, wainscoting, cases for windows and doors, for frames and sashes of all kinds, and for shingles. Most of the dwellings located within the districts where this tree prevails are built almost entirely of short-leaf-pine lumber, which bears ample testimony to its wide usefulness. It is also extensively employed in car-building, for cross-ties, and in the manufacture of furniture." In another place he says: "No other timber tree found in the southern portion of the Atlantic forest region is more easy of natural reproduction than this, throughout the wide range of its distribution. This is readily accounted for by its great fecundity, the seeds produced in great abundance almost without failure every year being profusely spread far and wide, and germinating easily whenever the proper soil and a chance are offered for their reception. By their thrifty growth the seedlings soon gain the upper-hand over the contemporary growth of other species."

Sudworth, in a paper on the "Forest Trees of Tennessee," says: "As is well known this pine (*P. echinata*, short-leaf-pine) ranks in commercial importance next to the famous long-leaf. The adaptation of the pine to the poor, dry hills and other sloping lands of East Tennessee is truly remarkable as seen in some localities. Theories that great care and nursing are necessary to re-establish a pine forest on entirely denuded land are easily controverted by the thousands of young short-leaf-pines taking possession readily, and in dense stands of old pasture and abandoned hills, and entirely without the nursing influence of broad-leafed kinds. Even under the damaging influence of tramping stock and invading fire, this young growth has gradually advanced, and solid phalanxes of saplings and middle-sized polewood now form a large part of the second-growth woodlands attached to farms, together with oaks and other hardwoods. There appears, therefore, to be no more useful and valuable concomitant in the future forestry of East Tennessee than this willingly self-propagated short-leaf-pine."

Now and then a beautiful seedling forest, naturally regenerated from adjoining woods, may be seen in New Jersey, and, as in the eastern peninsula of Virginia, if this species is favored, in the course of time it will be the rule and not the exception. It is not difficult, however, to secure a good stand by sowing the seed, provided the seed is fresh and fertile. The easiest and cheapest way is to plant the seed mixed with dirt in rows, or in narrow strips, across the field, four or five feet apart.* The best way to prepare this seed-bed, in case the land is not too stumpy, is to run a narrow, one-horse scratch-harrow over it, and then, after the seed is sown, run the harrow over the same strip again, in order to cover the seed. If one man strikes out the strips with the harrow, while another sows the seed, a large area can be covered in a short time. Where a horse and harrow cannot be used, it is best to work in the seed with a rake. Throughout the south swine prepare this seed-bed. After the seed has been sown, if the soil is very dry and sandy and liable to shift, the strips must be covered with pine-chats and brush, on which a little sand may be thrown to hold them down. As soon as the young pines form a closed canopy thinning should begin, and continue throughout the whole period of their life, so that the trees may have sufficient space and light and yet free themselves of limbs. The removal of litter and the time of cutting depend entirely upon circumstances. If the owner needs the litter it is proper to remove it; if he wants poles or small pilings there is nothing to hinder him from cutting his forest in the pole-stage.

---

* A good stand of the short-leaf-pine has been secured by spreading the pine twigs with ripe cones attached over the land

Red-cedar (*Juniperus virginiana*) is an excellent tree for the dry sandy upland. No American tree has a more interesting and instructive œcology.* It ranges from Cape Cod to Vancouver's Island, from Canada to Florida. In the north it inhabits dry, rocky uplands; in the south it grows in swamps, which are often covered with water; in the rich bottom-lands of the Mississippi Valley it is a lofty and noble tree; in the limestone regions of northern Alabama it is almost a bush; and along the shores of New Jersey it is flat-crowned and irregular, but a beautiful tree in spite of shifting sand and salt sea breezes. The quality of the wood also depends upon the region in which it grows. In many places it is of little worth; in others it is excellent in quality, strongly aromatic, rich red in color and famous the world over for pencils. It is one of the commonest trees in Southern New Jersey, quickly producing a highly prized wood on soil the surface of which at least is sterile. Its fruits are devoured by birds which scatter its seeds. When growing alone it is pyramidal in shape, with many branches. Sometimes the twigs and leaves are stiff and prickly; sometimes soft and pendulous. The wood of these knotty trees is extremely beautiful, and the limbs are of use for boat knees, rustic fences, etc. It is also an excellent wind-break, although subject to a fungous disease which infests the apple and quince.†

---

*The basis of silviculture is œcology or the science of trees in relation to their environment, many of the most important points of which in reference to American species are unknown. Much may be learned of the habits of trees by studying them in regions in which they are not indigenous. More is known of the silvicultural peculiarities of several American trees in Europe than in America. A careful study of the tropical forest will throw light upon many physiological problems, especially those which have to do with climatic conditions (see *Haberlandt's Tropenreise*). It behooves the Americans to emulate the Dutch in Java and the English in India, and establish in their new possessions experiment stations, schools and laboratories where northern students may study plant physiology, the *sine qua non* of agriculture and silviculture.

† The cedar-apple (*Gymnosporangium macropus*) is common throughout the State, and is of special interest because it leads a dual life, one phase of which is on the red-cedar (*Juniperus virginiana*), and the other has the cultivated quince, apple and their allies for its host plants. On the twigs of the cedar it causes brown, irregularly lobed excrescences, as large as chestnuts, over the surface of which there are slight indentations or centers in which the teleutospores are located. These spores are thick-walled, brown, two-celled bodies, which in warm, moist spring weather, germinate, that is, the cell-wall breaks, and there protrudes from each cell of the teleutospore a hypha or tube on the end of which several small spores or sporidia are formed. All the germinal tubes from one center adhere together, forming an orange-colored, gelatinous, tentacle-like growth. Several of these gelatinous masses, distributed over the surface of the whole excrescence, give it the appearance of a crysanthemum a short distance from the tree. Very often many hundreds of these may be seen on a single tree, and when they are in the height of their germination are peculiarly striking. The sporidia are borne long distances by the wind to the young, tender leaves of the apple and quince, on which, if the conditions are right, they soon germinate, and produce the other stage of this peculiar disease, which, on its orchard hosts, causes the well-known "rust." Although this fungus does practically no injury to the cedar, "the rust" is a very serious disease, especially in the south. It is more dangerous to quinces than to apples. The spores can be carried by the wind several miles. Although not wise to plant orchards in the neighborhood of red-cedars, or *vice-versa*, this disease is not of sufficient seriousness to discourage the propagation of the red-cedar in South Jersey, because the apple industry is there of little importance.

The young red-cedar trees are difficult to transplant in dry sandy soil, and the seeds, although abundant and easily collected, rarely germinate evenly. I have been told that nurserymen bury them in a "rot-heap" for two winters and a summer, and sow them the following spring. (The same is true of the holly [*Ilex opaca*].) The wood of the cedar, even when knotty, is in demand for posts; the quality produced in Southern New Jersey is excellent and there is little land too dry and sandy to support it.

Of the hardwood trees, the most valuable for the dry uplands of New Jersey is the *Robinia pseudacacia*.* In the Region of Bordeaux, where the soil is similar to that of the Coastal Plain of South Jersey, extensive private plantations may be seen. For this purpose, especially on small farms where fencing is an important item, the locust has no equal in spite of the depredations of the borer. In California, I have been told, the borer does not exist, and that in twenty years a locust tree in the open attains a diameter of as many inches. It is claimed by some that the injury caused by this insect is less if other trees are planted with the locust. It is excellent for planting in open places in the forest in the form of hursts, here and there, or as a fringe to pine plantations especially along railroads because it is not inflammable. The locust grows rapidly on poor soil, produces an extremely useful and durable wood and an ash richer in inorganic constituents than the majority of hardwoods. As

---

*A great disadvantage of the locust is the fact that it is seriously infested in this country by the locust-borer (*Cyllene robiniæ*). It was indeed fortunate for Europe that when the locust was introduced this pestiferous insect was not imported with it. In Europe, it is a beautiful shade and ornamental tree; in its native land, owing to the depredations of this insect it is usually unsightly. The trunks and limbs are sometimes completely honeycombed by this insect. If the trees are watched in August and September, one is likely to find handsome brown and yellow banded, wasp-like beetles, laying oval, dull white eggs in wounds and crevices of the bark. In about ten days these eggs hatch and the larvæ bore into the tree. They are still small by winter, during which time they lie dormant in the wood. In the spring they begin to bore, until about August, when they stop feeding and enter the pupa stage, and a week or so later appear as full-sized beetles. These beetles live upon the pollen of the golden-rod. The outermost trees are usually completely riddled, while those in the center of a group may escape altogether. It seems to suffer less also when mixed with other trees. Although these insects are very abundant and seriously injure the wood and impair the vitality of the tree, it is still fit for fence posts, for which it is almost exclusively used. This insect infests healthy trees, growing on rich soil, but the proportion of trees in a plantation which is thus seriously injured is not sufficient to discourage the propagation of this unique and extremely useful tree. Owing to the depredations of the locust-borer it is always best to mix another species with the locust. For this purpose ***Prunus serotina*** and the American chestnut are excellent. The wild-cherry (*P. serotina*) is worthy of more encouragement than it has heretofore received. It grows on poor soil, is easily propagated, yields an excellent wood, and attracts birds which are fond of its fruits. Mr. J. H. Schober, the pioneer of heath planting in Holland, who is experimenting with many species of foreign trees on his plantation at Schovenhorst, was loud in his praises of this tree and pronounced it one of the most promising of his vast collection.

with other leguminous plants, bacteroids, which reside in a symbiotic state in tubercles on its roots, are able in some mysterious way to accumulate nitrogen. The litter, which is rich but thin, quickly decays. Once established, the locust hurst will never need renewal; hundreds of stool-shoots and root-suckers are present to take the places of felled trees on the admission of light. Besides a tap-root the locust has an extensive horizontal root system by which the soil is held in place. It is for this reason used on railroad embankments and dry soils subject to shifting. The wood is useful for posts and other purposes, even when young, and is therefore of great value for private planting. Both red cedar and black locust may be sown in the same way that I have indicated for the pine. The seeds of the locust, if planted in the spring, should be soaked in warm water for three days before planting.

The white-cedar (*Chamæcyparis thyoides*) is the choicest of the soft woods of Eastern America. Not even inferior to the famous pumpkin-white-pine. In fact, for boat and tank construction it has no equal. The wood is light, soft, clean, easily seasoned, and remarkable for its durability.* It neither warps nor checks under the most trying circumstances. It is extensively used for bridge-plank, shingles, weather-boards, interior finish, and in the construction of fences either in the form of rails or palings. It has a pleasant cedary aroma, and when exposed to the weather becomes a beautiful steel or lichen-gray color.

The white-cedar should be grown in the form of a pure crowded wood, on wet mucky or wet sandy soil. The canopy should be uninterrupted, and the lower limbs should interlace. If the forest is too thin, irregular, with all age classes and here and there other species, the trees are easily uprooted by the wind, owing to the slight hold which they have upon the soft mucky soil. The stand should be so thick and the lower limbs interlace to such an extent that the tree will free itself from branches, produce clean boles and prevent the growth of underbrush. Owing to its sharp, conical top it endures close planting, although regular thinnings are necessary almost throughout the whole period of its life.

---

* The bark of the white-cedar is tough and fibrous and similar to coir in nature. Many trees of this species in South Jersey have been ruined by the fishermen, who use strips of the tough bark on which to string their fish. In Russia the manufacture of mats, rope, etc., from bark is an important industry, and in New Jersey the white-cedar bark might be used for similar purposes.

In this way, even in America, the forest will yield a small but constant income, since there is some demand for cedar poles. When sawed in half, barked and soaked in preservatives, these poles, even when very small, are of use in the construction of fences. In spite of the common use of wire, there is still in America great demand for good fence material. These saplings are useful for vine-props, masts for small boats, handles for rakes, boat-hooks and the like, racks for wagons and stalls, flag-poles, plaster-laths, fence-palings, and even shingles. In fact, from the time the tree reaches a diameter of three inches it is useful.

If a cedar tree becomes covered with gray lichens, as is often the case, it indicates slow growth, unhealthfulness and unsuitable environment.

The cedar is a great seed-producer, even when quite young. The seeds are formed in small cones and are easily collected. A pure stand of cedar may be secured in three ways. If one has a mixed deciduous swamp, with here and there a cedar, as is common, the easiest way to convert it into a pure stand of cedar is to cut and keep down all trees except the cedar. These seed-trees, with the admission of light and air, will produce an abundance of seed. A stand of cedar produced in this way may be irregular and uncertain. Perhaps the easiest and quickest way to secure a stand of this tree is to plant it. Young cedars are constantly invading cranberry bogs where they are very unwelcome. These can be easily secured in large numbers, and are better for planting than the spindling specimens from the woods. Another way is to sow the seed. After removing all the trees and brush from the place where a cedar stand is desired, when not too dry, it is best to burn over the surface, and then sow the seed mixed with dirt.

Among those species which grow with surprising rapidity, even on poor soils, and which may be easily propagated, the cottonwood or Carolina-poplar (*Populus deltoides*) deserves first place.

In speaking of this tree in his bulletin on the cultivated poplars, Prof. Bailey says: "Taking all things into consideration, the cottonwood is probably the best of the poplars for general ornamental planting. It grows rapidly and in almost every soil, and yet it possesses an air of strength and durability which most of the poplars lack. Its foliage is always bright and glossy, and the constant movement of the broad, rich green leaves gives it an air of cheeriness which few trees possess. The tree has been much used upon the western prairies and in western towns much too abundantly for good landscape effects. The rapid growth of the tree gives a feeling of luxuriance to plantations, even when most other trees appear to be weak or starved. The cottonwood grows best upon rather low lands, and yet it is generally an admirable tree upon high and dry areas."

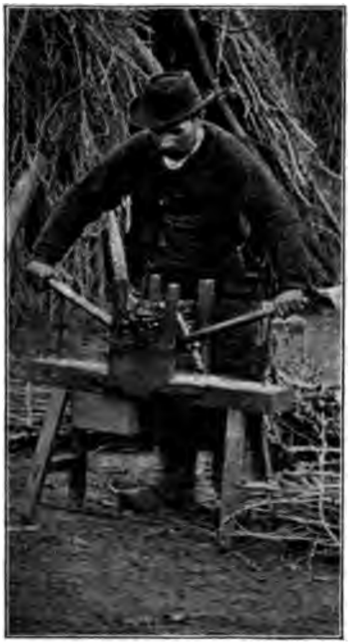
The so-called Carolina-poplar, according to Prof. Bailey, is only a very luxuriant, cultivated form of the cottonwood. Like the locust, the cottonwood has an extensive root-system, and reproduces itself profusely by means of root suckers. It is, therefore, excellent for holding the soil in place.

The wood of this tree is extensively used in the manufacture of paper, and there is no reason for supposing that the demand will not increase. This tree grows perfectly on the moist pine-barren land of Southern New Jersey, and I can see no reason why its cultivation should not be encouraged.

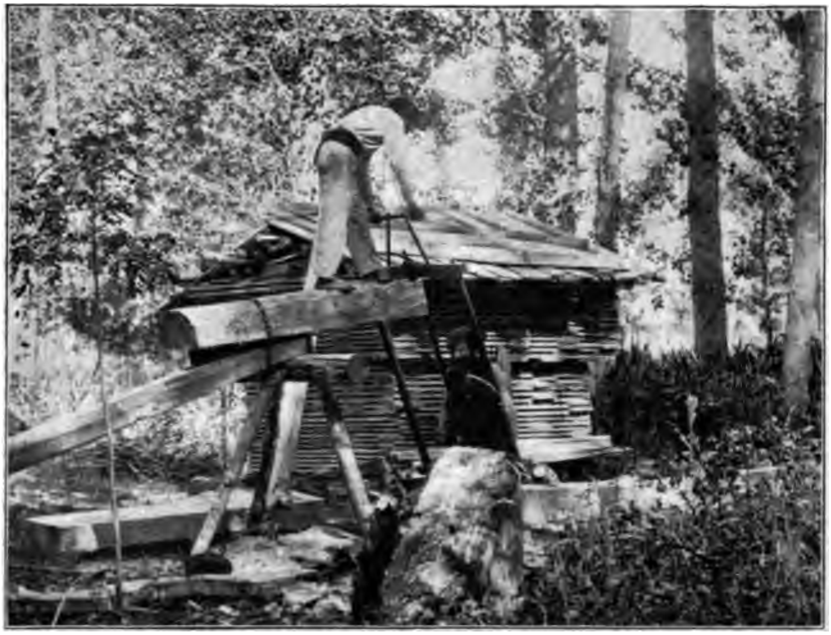
Throughout southern Europe the poplars are extensively planted by the owners of small holdings. These tall straight trees form a characteristic feature of the French and Italian landscape. They prefer poplar, because the trees are easily produced from cuttings, because they soon grow to a size fit for boards, because they yield the peasant loppings for fuel, and because they throw so little shade that grass and other crops will grow between the rows. Plate XXIV shows a peasant binding poplar loppings in fagots for fuel, and a peasant sawing boards by hand from poplar logs which he has probably raised from cuttings of his own planting.

This leads us to the consideration of those persons who possess small tracts of land in South Jersey out of which they must earn a livelihood. The land has been undergoing such a process of division of late that the average land-holder probably owns little more than a hundred acres. The day of the large farm in New

Plate No. XXIV.



BINDING TWIGS INTO FAGGOTS



SAWING BOARDS BY HAND IN FRANCE

Jersey is past. Owing to its nearness to excellent markets, general farming is being replaced by a more intensive form of agriculture, and old-fashioned crops are being replaced by specialties.

Hundreds of uneducated emigrants have invaded the Pines, owing to the cheapness of the soil and proximity to large cities. Few of these have brought with them European forestry ideas, and many of the most disastrous fires are those which they carelessly set in clearing their farms. Throughout this region there are German, Italian, Russian and other foreign colonies. By thrift and frugality many of these have produced fruitful farms on soil that was formerly waste-land, indeed it is claimed that owing to the warmth of this silicious soil, the fruits are earlier and sweeter.* It may be easily worked with one horse and few implements at any time when not frozen, and when abundantly fertilized and watered produces a superior grade of fruits and vegetables.

What the small farmers have already accomplished in this region demonstrates, without a doubt, that there are many latent possibilities in the pine-lands of New Jersey. Owing to the development of rapid transit and the cheapening of transportation rates, a migration from the cities into the neighboring country has begun. A large proportion of cultivatable land, therefore, is destined to be cleared and farmed, and to these prospective farmers I would suggest a "forest farm."

Suppose a person possesses one hundred acres of woodland, out of which he wishes to make a combination forest and farm. The first step is to clear a fire-lane around the whole of it, at least two hundred feet in width. This lane should constitute the cultivated portion of the farm. On this no inflammable crop should be planted.

Even the sandiest, driest land, when fertilized with the quickly disintegrating pine-chats, produces a fine grade of sweet-potatoes, which are richer than the white-potato, and together with game, fish and berries often constitute the whole food of the natives.

---

* It is very difficult to say just what lands are unfit for cultivation. Good agricultural soil may often be unfit for trees and *vice versa*. Even the "Plains" of New Jersey would, if properly treated, produce choice grades of grapes, berries and sweet potatoes, and perhaps other fruits. In North Jersey the choicest peaches are produced on what is apparently the roughest and most inhospitable soil. Many Italians have thrifty fruit-farms on extremely sandy soil in the southern part of the State. A large percentage of the best land in Southern New Jersey is still in forest. In fact, in early times the land easiest to clear was cleared first regardless of the quality of the soil, and many of our finest farms were once true waste-lands.

If the one hundred acres referred to is perfectly square, a fire-lane two hundred feet wide around it would contain about thirty-five acres—as much as one man can comfortably till. There would be left in the center a forest containing about sixty-five acres to which the principles of silviculture I have already mentioned may be applied.

If the whole area of woodland in Southern Jersey were treated in this way, sixty-five per cent. would be left in wood, and the whole would be cut up in such a way that extensive fires would be impossible. The sixty-five acres of forest should be divided into about four blocks of fifteen acres each, by lanes or avenues wide enough to permit a wagon to pass. These lanes should be kept clear of litter during the fire season. If part of the land is swamp-bottom the owner is fortunate. He can easily have a white-cedar hurst, a cranberry-bog and an osier-holt, which will add materially to the profits of his farm.

Owing to the fact that these swamp-lands shrink and become lower and damper on being tilled, unless assiduously drained it is better to plant crops which need little or no cultivation, such as forest crops, willows for baskets, the high-bush-blueberry and the cranberry.

Willow culture is destined to become an important industry in this region. The first to begin it on damp pine-barren land was the Baron de Hirsch Colony of Russian refugees. The willow has been righty called the Cinderella of trees. It will grow on land which for other purposes is almost hopeless. Its pliant twigs are excellent for trunks, boxes, crates, etc., besides baskets. It furnishes work at a season of the year when there is little else to do. It is a good plan, as is common in Europe, for one member of the family to learn the trade of basket-making. In this way a local industry is produced.

In addition to these industries, if progressive, the owner of the "forest-farm" could keep both bees and poultry with profit, even in the most remote and barren part of this whole region.*

---

* Every enterprising farmer should have in the corner of his garden a permanent seed-bed. It should be boxed on the sides and ends with wide strong boards and covered with fine poultry netting which should be nailed to a frame so that it can be easily removed. The soil of the bed should be a soft, rich, sifted loam. Whenever the farmer in his travels finds seeds of trees which are desirable he should sow them in this bed. While the trees are still small he should transplant them to his wood-lot. In this way, little by little, and with the expense of only a little labor, he can supply himself with seedlings and gradually improve the condition of his forest.

Apiculture, although it requires considerable skill in manipulation, should be a subsidiary forest occupation. This has been strongly recommended to the forestry people throughout Europe who have their homes in the forest. In South Jersey there is abundant bee pasturage. The locust, the linden, the catalpa, the chestnut, the red-maple, the hazel, laurel, huckle and blue-berries, grape vines, willows, holly, persimmon, magnolia and a host of other plants, yield honey, or pollen. From pollen bee-bread is manufactured on which the larvæ are fed. From buds, etc., the bees collect a viscid glue, or propolis, with which they strengthen their cells, and fill up the cracks in their hives as a protection against cold.

In order to secure a fine type of bee it is necessary to supplant the native queen with one of a better variety, either Italian or Carniolan.*

Besides gathering large quantities of honey, bees materially increase the fruit and seed crops by fertilizing the flowers.

Poultry-raising is also an important subsidiary occupation. In the dry soil and mild climate of the Pines chickens and turkeys, and along the rivers water-fowl, thrive, securing throughout a large portion of the year their own livelihood, and at the same time do incalculable service to the forest farmer in restraining insects.†

It is, in short, through a combination of several of these industries, which are minor only in name, that forestry and farming may become profitable on soil which is not naturally fertile and where many people own only small areas.

The destruction of vast areas of forest without regard to the future has a deleterious sociological effect upon the standard of life and character of the people of such regions. In South

---

*The domestic bee in America (*Apis mellifica*) was introduced by early settlers from Europe. They have multipled and become common. The Cyprian race from the Island of Cyprus has produced the largest yield of honey on record for a single colony in America. They are the most assiduous of bees, but are very sensitive and require great care in manipulation. The Italian variety is also famous and easier to handle. The gentlest of bees, however, is the gray race of the Mountains of Carniola (Krain, near the Adriatic) in Austria. This bee is steadily growing in favor in America. See "The Honey Bee," by Frank Benton, publication of the U. S. Dept. of Agriculture.

† While visiting the Dunes of Holland I was told that hens were successfully used to combat an insect which devoured the sedge which held the sand. They were kept on the dunes in large quantities and as early as three o'clock in the morning were actively at work. I was also told by several willow-growers in Europe that when their plantations become infested with insects they simply let in their chickens, which soon devour the bugs. One of the most beneficial fowls in this respect is the turkey.

Jersey, for instance, owing to the exhaustion of saw-stuffs there are many deserted hamlets and silent sawmills. It is true that on the whole the population is on the increase, but this is due to another class who have come from elsewhere with other abilities and other objects in view. Many of the natives, however, who were born and bred in the forest and earned their livelihood in the woods have been forced to leave for other regions and engage at a disadvantage in other work. The few who have remained of this class are in a state of stagnation, and in many instances, were it not for the berry crop and the game in the woods, would die of starvation. Owing to the fact that they are idle a large part of the year, that they are far from neighbors except of their own class, that they are often insufficiently fed and clothed, there is little wonder that many are outlaws. The backwoodsman without work is the man who sells his vote. The common schools of America are endeavoring to educate such people, but much of the good influence is offset by the industrial depression which follows the wasteful destruction of wood in a country where the majority of the people are woodsmen. Just as reckless deforestation inevitably leads to idleness, want and moral degeneration among those dependent upon the woods, so does afforestation have the opposite effect in the same if not greater proportion.

Then, too, the value of forests from a hygienic standpoint on swampy soils has been underrated. I believe the malarial condition of our South is due to the ill-treatment of forest lands and the formation of stagnant marshes in consequence. It is a noteworthy fact that the Dismal Swamp of Virginia and North Carolina is free from malaria and perfectly healthy, while the adjacent fire-swept pine-lands are famous for their unhealthfulness. Just as the Landes of France were rendered healthy by tree-growth and drainage, so is it possible to improve the sanitary condition of the Atlantic Coast Region.

III. Parts of Europe Similar to Southern New Jersey.

In Europe there are still immense tracts of waste-land, a large proportion of which has been robbed for centuries, until much of it is now in a state of extreme poverty. The majority of this land is worse, although similar, to the Plains of South Jersey. The system of removing not only the turf but the surface soil from these wild-lands is ultimately worse than the effects of forest fires. A forest fire in sweeping over a country leaves something behind it. The inorganic materials which the plant took from the soil are returned to it in the form of ashes, and although a part of them may wash away, something is left; but in the heathlands of northwestern Europe the very surface of the earth is scraped together, so that in the course of time the soil becomes bare and sterile. We usually think of Europe, and especially Belgium and Holland, as the places of all the world where every spadeful of earth has been turned over hundreds of times, and where every effort has been exerted to provide room for its swarms of people. One is surprised, therefore, to see a new settlement called "America" in the midst of a great unsettled plain in Holland. There are, in fact, in this little country, from four to five hundred thousand hectares * of waste-land, which consists of heath, moorland and morass. The Dutch prefer, and perhaps wisely, to grapple with the mud and water along their shores. They would rather farm into the jaws of the sea than work on their dreary heathlands. Mr. Schober, at Schovenhorst, has been striving for years, at great expense and with great perseverance, to show what is possible on the heathlands of Holland by careful cultivation and improved methods. But just as the Swiss loves the steep mountain sides, so does the

---

* Centare (1 sq. meter)=1,550 sq. in. Are (100 sq. meters)=119.6 sq. yds. Hectare (10,000 sq. meters) =2.471 acres.

Hollander love his muddy soil. This soil, although difficult and expensive to reclaim, when once in shape is almost inexhaustibly fertile. The fine sandy land of Holland has also been carefully cultivated, and the dunes along the shore have been carefully watched and patched here and there because they serve as dykes along the sea. One of the most attractive regions of the Low Countries is in the lee of the Dutch dunes, where there are many beautiful villas and gardens.

Although much has been done toward the reclamation of waste-lands, the common notion that every inch of territory in Europe is used to good advantage is a mistake. In fact, Europeans could learn much in reference to land reclamation even in the United States, where good land is still cheap and abundant. Much has been done, for instance, in this line in the banked lands of the Mississippi Valley and the irrigated deserts of the Far West. There is little that one can learn in Southern Europe outside of France and Italy, except the disastrous effects of deforestation. Although much that has been done in Europe is highly commendable and suited to the peculiar conditions which exist there, it would be difficult to say just how much of it is applicable to America. There is one important difference between the New and Old Worlds which should not be overlooked in all considerations and calculations. It is the fact that in general in Europe labor is cheap and materials expensive; in America the reverse is the case. Much of the detailed and extremely careful work which is devoted to small and unimportant things may pay in Europe but not in this country. One cannot help admiring the pains and patience of these people, but at the same time in another country, under different conditions, they would themselves do otherwise. Carefully saving and binding together small sticks into bundles for fuel is all right for the places where fuel is scarce and expensive, but would be decidedly out of place in America. European sawyers are horrified at the sight of a circular saw with wide kerf buzzing at a rapid rate and wasting a large proportion of the log, but it saves time, and time has been up to the present more precious than wood.

Europeans are generally conservative, especially the peasants, preferring to do as their fathers did, working often to great dis-

REPORT ON FORESTRY

Plate No. XXV.

advantage with implements which are decidedly clumsy. And then, too, all sorts of traditions and customs, rights and servitudes have been handed down from generation to generation. The poor peasant is often fettered by these inheritances, which he joyfully leaves behind him when he enters a new and fresh land.

In parts of France forest fires are still quite common, even on land which has been reforested, while in other parts wood is too precious to burn even for fuel. In Italy lumber is one of the scarcest of materials, although there are vast areas of waste-land where wood could be raised to advantage, especially on the bare mountain peaks. It is a land of few wood-workers and many masons, where even the vine-props are often granite.* The supply and demand are more local in Europe, and transportation suffers from all sorts of hindrances. A board would pass through more vicissitudes in going from Germany to Italy than a bundle of shingles would in reaching New York from Oregon. This is not so of water transportation, which is of course less hampered by governmental interferences.

In many districts in Europe the inhabitants depend upon turf for fuel, which exists in almost exhaustless quantities in the heathlands of the north, and even in Germany it is not uncommon to see peasants drying cow-dung for the purpose.

In parts of the Plain of northwestern Europe, under the peat, have been found pine stumps and the stone implements of the aborigines. Another page in its history is illustrated by oak stumps, among which have been found bronze axes and other implements. Here and there are beds of peat buried under the sand, indicating that the soil has been shifted hither and thither by the wind. It is generally believed, however, that the great heathlands of northwestern Europe were never densely forested, and that the trees existed in the form of groups here and there. Such places were well suited to the nomadic pastoral stage of man's existence. This, to a certain extent, still lingers in the form of the shepherd tending his "snucken" or little black sheep on these broad heath-covered plains. There, too, one often sees a bee-keeper surrounded by many hives of little black bees, which he moves from place to place for fresh pastures.

---

* "Forestiere" in Italian means a stranger—that is, a person from the forest.

The Belgian Campine.

The first region that I shall refer to is the Belgian Campine, a large tract of sandy land in the vicinity of Antwerp. In wandering over this region one sees much that reminds him of the plains and barrens of Southern New Jersey. The bushy oaks, the scrubby pines, sandy or gravelly soil, and many plants of the heath family which cover the surface, are strikingly similar to those of Jersey. Here and there in this region are small houses of the Flemish farmers who often have a hard struggle in squeezing a livelihood out of the soil. Most of these peasants plant forests of pine with short rotation from which they get humus for their compost heaps and fuel-wood. It is not uncommon to see a woman and a dog in harness tugging together at a load of manure, or a man in the field plowing with a cow which is usually at the same time milked. The house and barn of the peasant are combined, and the manure-pile, which is close to the door, is his most precious possession. Now and then green manuring is practiced, and a field of yellow lupine[*] is quite as beautiful as a field of crimson clover.

Much that I have to say here in reference to the Belgian Campine was suggested by a little book entitled "La Culture du Pin Sylvestre en Campine," by L' Abbé G. Smets, professor of agriculture at Hasselt, in Belgium. To this I have added my own impressions and have compared the two wherever possible. A large number of the Belgian Scotch-pine (*Pinus sylvestris*) plantations leave much to be desired. The trees are stunted and grow to a height of only a few meters. The volume growth rapidly attains its maximum, and even at the age of twenty years some of the forests begin to die. Parasites are abundant.[†] There are few old trees; the quality of the wood is poor and the best stands, according to Smets, yield small profits.

---

[*] I have endeavored to grow this lupine (*Lupinus lutea*) in South Jersey from seed bought in Holland, but it failed to flourish both on good and bad soil, owing probably to the dryness of the summer. Our purple lupine (*Lupinus perennis*) is worthy a trial on very poor, sandy soil.

[†] In the pine forests of Northern France and Belgium a wood-eating insect known to entomologists as *Hylesinus pini perdo* attacks the pine in swarms. This little beetle bores into the young branches and tunnels along the medullary canals. The wind snaps off the damaged twigs, and now, in some pine districts, the forest floor is fairly strewn with the debris. The insect develops very rapidly under the bark of felled trees, and it is found that barking the logs immediately after they fall under the axe prevents the spread of the pest.

M. Houba says, however, " that one must not expect too much of plantings on waste-land, and that the revenues from the poor-lands of the Campine and Ardennes are equal to five per cent. on the capital invested." (If American capitalists could make *sure* of five per cent. there would be large investments in forest land.)

Heathlands, which have not been exhausted by the removal of the humus, have produced satisfactory forests. " Nothing is sadder," says Verstappen, " than to pass over certain wooded zones of the Campine, to-day offering a spectacle of decay which seems without a remedy. Where thirty years ago one saw superb pine groves yielding as much as the best wheat-lands of Hesbaye, now one sees only rare groves of third and fourth grade, while the greater part of the surface is covered with a growth not exceeding three to five meters in height." Levasseur says that a good plantation of pine properly managed, well located, should yield, at the end of eighty years, 27,175 francs per hectare. That is, according to our system of measurement, $2,174 per acre, or $27.17 per acre per year! Prof. Smets estimates a yield of from 1,500 to 4,000 francs per hectare in a period of 30 to 40 years for the Belgian Campine. That is about a yield of $4 per year per acre for this poor heathland! If these figures are correct, the wonder is why every inch of that land has not been reclaimed.

The Scotch-pine will grow under a great variety of conditions. It is not very sensitive to frost and accommodates itself to low and damp places. It is a tree of the vast plains with silicious bottom and deep soil. It is a species easy to satisfy and has been successfully transported to many countries into many soils. It is probably the most widely spread of all the pines. It is like the red-cedar of America in respect to endurance, growing in wet and dry locations, in hot and cold, on mountains and in the lowlands. Very rarely, however, does it reproduce itself naturally.

Here and there, at a certain depth, a bed of impermeable clay or heath-humus buried under eolian sand arrests the growth of the trees. These beds do not exist everywhere and their bad effects may be overcome by thoroughly working and softening the soil. This all tends to prolong the life and vigor of the tree and render more available the nutritive elements of the soil, but even plantations the soils of which have been carefully prepared before planting, produce results which are far from satisfactory. "The poverty of the soil," says Smets, "is the general cause of the failure of the pine in the Campine." The idea has prevailed that the Scotch-pine can succeed everywhere, that it only demands a trace of nutritive elements, that every soil suits it. Although the demands on the soil by this pine may be less than other forestal species, nevertheless a soil may reach an almost hopeless sterile stage after years of cropping by the removal of wood and the surface humus and soil. It is well known, too, that trees on such soil are more subject to disease and quickly succumb. They are simply stunted by starvation. Young trees en masse are, it is said, as exacting in their demands upon the soil as a crop of rye.* Although, as I have already said in the previous chapter of this report, very little reliance can be placed in the chemical examination of a soil, the absence of one essential ingredient may compromise the whole crop. When a tree grows rapidly and reproduces itself abundantly, as occurs in the pine-lands of South Jersey, it is evidence enough, without chemical examinations, that the soil is in good condition, no matter how barren it may appear. In the Plains of South Jersey, which are treeless, only one essential may be lacking or the difficulty may be a physical one. According to Schütze, pineries may be classified as follows:

	Phosphoric Acid, Per cent.	Potash, Per cent.	Lime (Chaux), Per cent.
Pinery, 1st class, ...	0.0501	0.0457	1.8876
" 2d "	0.0569	0.0632	0.1622
" 3d "	0.0388	0.1221	0.1224
" 4th "	0.0299	0.0392	0.0963
" 5th "	0.0236	0.0241	0.0270
" 6th "	0.0236	0.0215	0.0458

The Expt. Station Record gives tables which, in general, show the limits assigned to rich and to poor soils. They are as follows:

---

* The sands of the Golden Gate Park were so poor in nature that barley sown on its surface after being ploughed and cultivated in a favorable season with plenty of moisture, grew only about six inches in height and failed to perfect its seed. After planting sea grass to fix the sand and lupines to enrich the soil, the trees which were planted only grew to a height of ten feet, owing to the lack of nutriment in the soil. See the Reclamation of Drifting Sand Dunes, in the Forester, for October, 1899.

	Nitrogen.	Phos. Acid.	Potash.	Lime.
Very poor soils, ...	0.05 %	0.01 %	0.05 %	0.10 %
Poor soils	0.05–0.10	0.01–0.05	0.05–0.10	. . .
Medium, ...	0.10	0.05–0.10	0.10–0.20	1.00
Rich, ...	0.10–0.20	0.10–0.20	0.20–0.30	. . .
Very rich, ...	0.20 up	0.20 up	0.30 up	2.00

According to this the treeless Plains, as far as the soil is concerned chemically, except in the quantity of lime, if these analyses are correct, have a first-class pine soil. The soil of the Jersey Plains contains the following ingredients:

	Sample I.	Sample II.
Nitrogen, ...	0.06	0.03
Phosphoric acid.	0.07	0.065
Potash, ...	0.05	0.02
Lime, ...	0.06	0.02
Silica, insol., ...	96.40	96.95
Alumina, ...	1.15	0.28
Ferric oxide, ...	0.40	0.20
Ferrous oxide, ...	1.26	1.06
Magnesia, ...	0.04	0.02

According to Smets, the soils of the Campine contain the following proportions of ingredients:

	Azote.	Phosphoric Acid.		Potash.		Lime (Chaux).		Magnesia.	
		Sol. in H cl.	Insol.	Sol	Insol.	Sol.	Insol.	Sol.	Insol.
Pine land. .	0.06	0.013	. . .	0.013	0.648	0.004	0.959	0.023	0.260
Pine land .	0.040	0.012	. . .	0.032	2.026	0.055	0.950	0.033	1.291
Cult'v'd soil,	0.122	0.034	0.010	0.005	0.459	0.027	0.624	0.011	0.052

According to these analyses, even the Plains of South Jersey, if ploughed and worked, then planted with a leguminous crop, then ploughed again and limed and then planted with pines, would probably produce a good crop, provided the soil is not too dry. Very often a leguminous crop, such as cow-peas, may not take the first trial owing to the absence of bacteroids in the soil so that several attempts may be necessary. This probably would not pay, but it would be an interesting experiment. It is claimed by many that forests do better on soils which have been cultivated for a time. The soil is mellowed by the process of cultivation, and the inorganic materials which have leached through the surface during the process of cultivation are reached by the roots of the trees. Pines which spring up in old abandoned fields are very vigorous, and in Virginia signs of the old corn-rows may be seen in forests on land which produced cotton and corn up to the time of the Civil War. At the same time the materials which have escaped the field crop by leaching are brought again to the surface by the tree so that the soil is being rendered fit again for agricultural purposes. The forest is thus an important factor in the rotation of crops, as I have already explained in the first chapter in connection with the eastern shore of Virginia. Although the farmers in that region remove the litter, they wisely allow old fields to come again in pines and clear fresh pine forest. By making the rotation of the pine short, the growing of pines in the sand-lands of the South may in time play an important agricultural rôle, and may, as one in the series of several crops, be necessary to maintain the productiveness of the soil.

It must not be forgotten also that the roots of trees corrode even the silicates, and coarse sandy soil, under the influence of vegetation, becomes gradually loam-like in nature, although clay may be lacking. For this purpose pines have great advantages in that they are adapted to sandy soils and that the stumps soon rot after the tree is cut. It is not a difficult task to clear a pine forest for agricultural purposes. In planting old fields the surface should be plowed under in order to bring fresh soil to the top. The young crop demands a rich surface-soil; later, when the roots penetrate into the subsoil upon which the tree feeds, it can take care of itself. Smets recommends, therefore, the growing of young plants in nurseries in good soil first, and claims that the so-called hardening of plants by growing them under adverse conditions is a mistake. This is, of course, expensive, and is not necessary in a country where a good crop is usually produced naturally or may be easily produced by sowing.

There is formed in the heathlands of the Campine a peculiar powdery dry light-brown or black humus which decomposes with difficulty and collects in thick beds. It is formed mainly by the stems and roots of heather. It is acid or sour in nature and sufficient alkali to neutralize it is lacking in the soil. It is, in fact, antiseptic in nature. This kind of peat does not form in Southern countries except in mountainous regions. The peat which is formed in the swamp-lands of New Jersey is of a very different nature, decomposing quickly, being comparatively mild or easily converted into a good fertile condition by drainage and cultivation. This mucky land is one of the best forest soils in New Jersey, being the home of the white-cedar (*Chamæcyparis thyoides*), our choicest soft-wood.

According to Smets the rôle of the pinery should be to prepare anew the soil which has been exhausted on the surface by agriculture or by the removal of humus.

Smets concludes that if the heathlands of the Campine are cultivated for a time, enriched by lupines and lime, and then planted with pine, they will produce fair forests, provided the humus and litter are not removed. In Hungary the pineries are limed.

In reading the government reports in reference to the Campine I have concluded that what is accomplished in Belgium in this line is accomplished under difficulties. The struggles we are having in America are no greater than those of other countries. There has been commission after commission, report after report, with all sorts of recommendations. In 1898 there were still 173,000 hectares of unreclaimed heathland in the Campine.

As an illustration of the peculiar difficulties encountered I shall mention "bud-stealing," which, although recent, is serious in its consequences. These pine buds, which are used in liquors and medicinal preparations, are collected and sold by the peasants. Whole families work at this industry, silently in the night, in young forests, in the springtime. The tree, when robbed of its terminal bud, grows crooked, and if the process is repeated stops growing and finally dies.

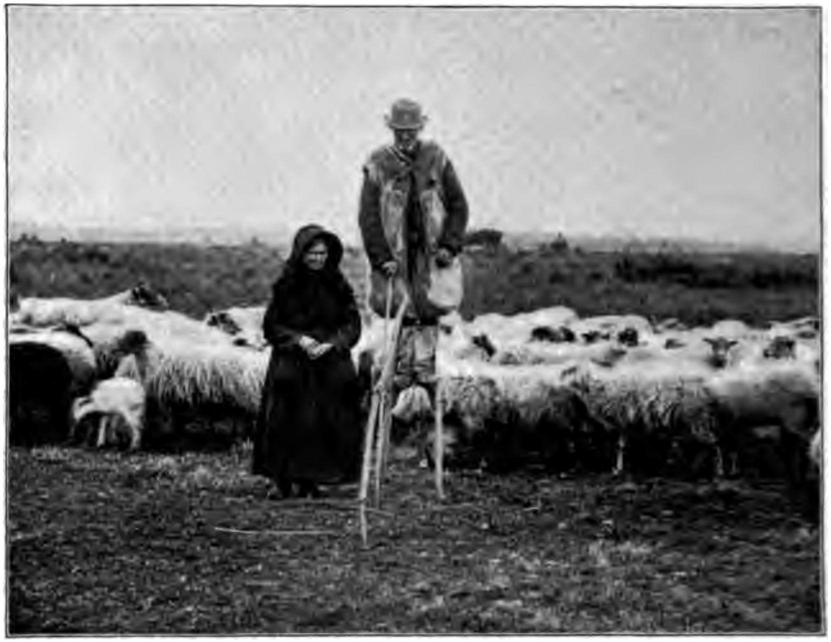
I shall conclude this section with the statements that with the exception of the Plains the whole of South Jersey is quite equal in timber-producing qualities to the better portions of the Campine. Some of the finest forests of the world, in fact, are on soil no worse than the Jersey sands. The magnificent forest of Fontainebleau (40,000 acres), for instance, is on a bed of dry sand. Remove this forest, and 98 per cent. of it would become a desert of drifting sand. It should always be borne in mind that sandy soils in regions in which there are sufficient warmth and humidity, if left to nature and freed from the pernicious interference of the human species, fires and browsing animals, will in the course of ages become forest-clad and fertile. By forest-clad I do not mean a meagre growth of trees and bushes, but a rich, dense forest, with a soil which, under the influence of leaf-mold, will ever improve in quality, both physically and chemically. By the application of skill and knowledge this process may be, of course, hastened. There are French foresters who have said that were it not for the camels and Arabs of the Sahara the oases of vegetation would have gradually spread and covered a large proportion of that barren waste. On the other hand a magnificent forest on fertile, sandy soil can be quickly converted into a sterile desert by the reckless removal of fertility from the surface. Those lands in Southern New Jersey which are being subjected to the same or similar processes through which the Campine of Belgium has passed belong to the Beacon Hill Formation, which is mapped and described in the Annual Report of the State Geologist for 1898.

In referring to this region, Mr. Knapp says: "In the vicinity of Hammonton many clearings have been made on this formation and have been found to be profitable for the cultivation of berries. It is possible that considerable tracts elsewhere might be used in the same way, but at present a very small proportion only of this formation is in cultivation. The formation as a whole seems to invite forest culture rather than the ordinary form of agriculture." He also assures us that although the soil is coarse, loose and white, its surface appearance is worse than its real character.

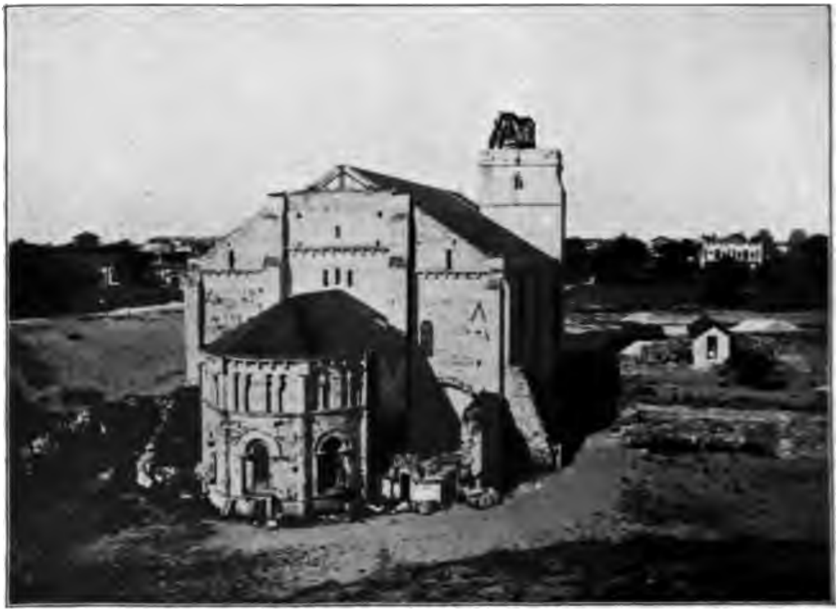
The Dunes and Landes of Gascony.

In this chapter I shall refer mainly to the Dunes and Landes of Gascony, one of the stereotyped examples of the complete reclamation of an almost uninhabitable and unproductive waste-land. The two principal works I have consulted on the subject

Plate No. XXVI.



NATIVES OF THE LANDES



A CHURCH WHICH WAS BURIED BY THE SAND ON THE FRENCH DUNES are "Les Landes de Gascogne," by M. Chambrelent, and "Les Landes et Les Dunes de Gascogne," by M. Grandjean.

In the early part of this century (before 1857) the condition of this flat triangular plain, known as the Landes, which is roughly bounded by the Bay of Biscay, the river Adour, and the river Garonne and the Medoc, was, in brief, as follows: There were miles of marshy, almost treeless wastes, covered mainly with a low, dense growth of herbage. It was wet, unhealthy and sparsely inhabited. The few people who lived there depended upon their flocks. The accompanying picture shows a native of the Landes standing upon stilts watching his flock. (See Plate XXVI.) He is dressed in a heavy sheepskin paletot. By standing on stilts these shepherds can easily see their sheep in the herbage and can easily follow them through wet and marshy regions. Their spare time is spent in knitting stockings. The condition of the Landes was due to the immense sand dunes which arrayed themselves along the shore of the Bay of Biscay. They moved inland, covered villages and occluded inlets. The damage done by these moving sands so increased that the government officials studied the work and devised and executed plans, and now, thanks to de Villers, Chambrelent and Bremontier, the pioneer workers, the Dunes and Landes are covered with a beautiful growth of the maritime-pine. The region is now a famous health resort, combining the beauties and pleasures of the seashore with those of a well-managed pine forest which extends almost to the edge of the ocean.

There are evidences that the Dunes were naturally originally fixed by forests. These forests were destroyed by vandals and all attempts failed to stop these menacing mountains of sand. In 1778 a talented engineer, Baron Charlevoix de Villers, was sent to Arcachon for the purpose of forming a military post. He saw at once the necessity of fixing the sand, and was, according to Grandjean, the first to establish the fact that the way to fix the dunes is by the means of plantations of pine. He met with troubles in his work and was finally sent back to the Island of San Domingo.

In 1784 Bremontier began the work and, it is said, by using the result of de Villers' labors, finally succeeded in fixing the moving sand.*

---

* Bremontier tells cf a dune which advanced, in a violent tempest, at the rate of two feet in three hours.

Plate XXVI shows a church at Soulac which was buried by the sand.

The methods employed in fixing the dunes may be briefly described as follows:

A littoral dune was constructed straight along the shore from the mouth of the Gironde to Bayonne. This dune was the secret of the success in the fixation of these shifting sands. It is simply a bank of sand of certain dimensions, with a certain slope suited to the condition of affairs. This protective, or littoral, dune is formed as follows: a double fence is constructed of brush,* or of palisades driven in the sand. This stops the sand which comes from the ocean. Soon a ridge of sand forms, equal in height to the fence. A double fence is used, as it gives breadth to the dune, and stops the sand which blows through the fence on the ocean side. As soon as a ridge of sand is formed as high as the fence, the old fence is pulled up, or a new one built on top; and so on, until a dune of the height desired is formed artificially. The proper height of a protective dune is 33 feet. It should slope 25° towards the sea, and may be 60° on the land side. The dune must be at least 300 feet from high-water mark. After the dune has reached the proper size, it is kept in shape by the sea marram (*Psamma arenaria*).† This peculiar plant, called *gourbet* in France, is exclusively used for fixing the sand on the littoral dune. It has long, much-divided rhizomes, and will grow well only when covered with fresh sand. The dune must always be kept in shape. If sand accumulates in any one spot in undue amount, a draft is formed, which may end in a breach of the littoral dune. *Gardes cantonniers* are stationed along the dune, to watch it closely, and here and there on this long, straight sand-bank groups of men and women may be seen digging up the *gourbet* in places where it is too thick, and planting it where needed. Constantly the dune is watched and mended; the forest, villages and fields in its lee are dependent upon it, and it in turn is dependent upon the humble, but persistent, *gourbet*.

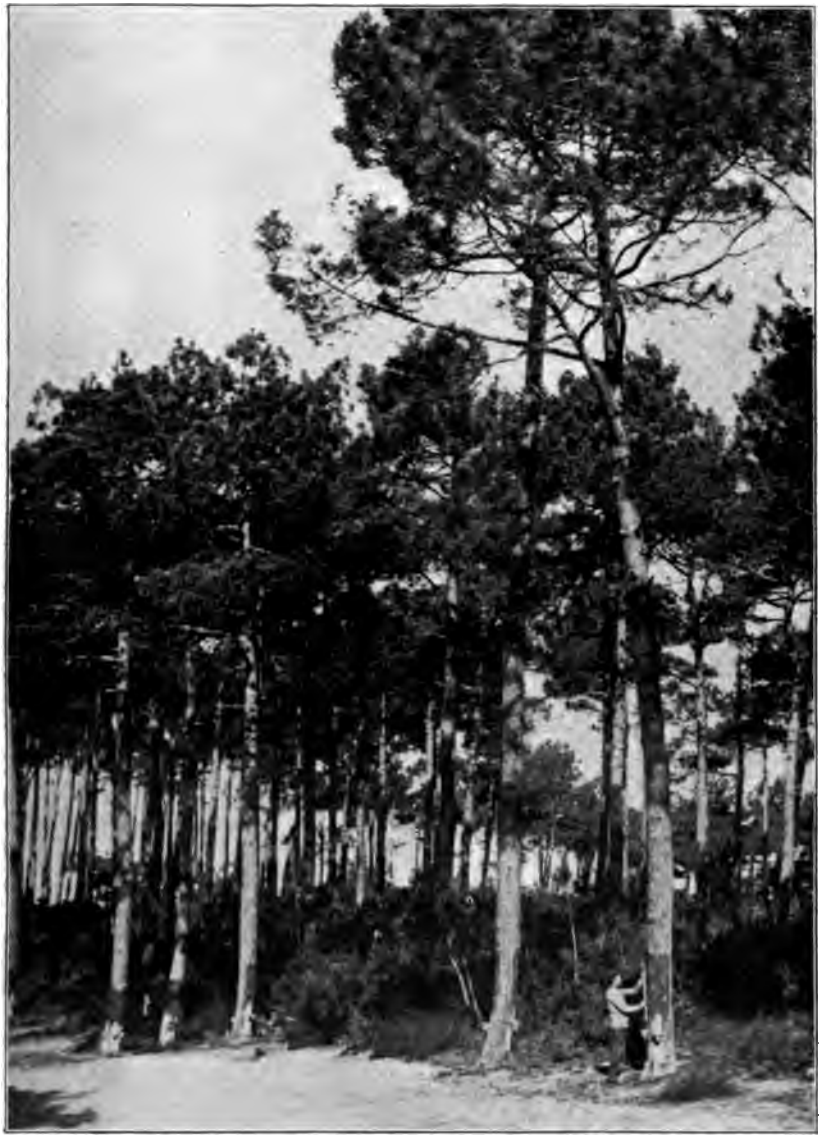
After the formation of the littoral dune comes the work of

---

* This system of making a fence of brush is called *Clayonage*.

†*Psamma* or *Ammophila arenaria*, beach or marram grass is the best known of the true sand-binding grasses. (See Sand-binding Grasses, by F. Lamson-Scribner, in year book of the Department of Agriculture.) It is common on the Atlantic coast of both Europe and America.

Plate No. XXVII.



FOREST ON THE FRENCH DUNES NEAR ARCACHON

planting in its lee. The surface of the sand is covered with brush arranged like the slates on a roof, with a shovelful of sand here and there to hold it down. Then the seeds of *Pinus maritima* are sown, with seeds of other plants to shade the young pines. The pines usually come up well, and grow quickly, although close to the littoral dune they are gnarled and stunted by the salt winds. Thus the sands are fixed, and, although the forests do not yield a large interest in cash, they are of incalculable value to a large proportion of the people of Gascony—in fact, indirectly, to the whole of France. Fire-lanes have been constructed across the dunes, and, thanks to the watchfulness of the guards and the rigid enforcement of laws, fires are not frequent. Owing to a lack of roads and means of transportation on these dunes, only the most valuable timber is marketed after being tapped for resin. If it is desirable to remove a tree, it is bled to death before being cut.

The fixation of the Dunes rendered possible the work of M. Chambrelent, which was the reclamation of the Landes by drainage and plantings. It is a unique example of personal initiative. M. Chambrelent, a young engineer in the Department of Bridges and Roads, in 1837 was sent to Gironde to study the drainage of 800,000 hectares of land in the districts of Gascony and the Landes. His conclusions were not accepted, so he bought some land and put into effect the measures he advocated. In 1855 the results of his experiments were submitted to an international jury. The jury was so favorably impressed that it recommended the application of Chambrelent's plans to the entire region, and in 1857 a law was passed requiring the Communes to do this work. The Communes paid for it by selling a part of this land which increased in value after the completion of the work. This region was one hundred meters above sea level, flat and sandy. It was underlain with a hardpan called "alios." In summer it was a bed of burning sand, in winter constant inundation, and between the two a period of pestilence. The country was characterized by its sterility and insalubrity.

A complete system of drain-ditches was dug and the seeds of *Pinus maritima* sown. In 1865 all works of drainage were complete. The pines grew with extraordinary rapidity. The "alios," which formerly arrested vegetation, in no way impeded growth. It is a sandstone, not entirely impervious, and served to hold the moisture during the dryness of summer. It was feared that the inability of the tap-root to penetrate this hardpan would arrest the growth of the tree, "but," says Chambrelent, "the uselessness of the tap-root * has already been demonstrated. It extends to inert soil which receives no atmospheric influences. It really plays only a mechanical rôle for holding the tree in place, but in close growth is not necessary, because the trees support each other."

He also notes the fact that in spite of very rapid growth the wood is of superior quality. In another place he says that, owing to its elasticity, the poles are in great demand in England for mine props, also that because of its rapid growth, the absorption of copper sulphate is facilitated, which renders it durable and valuable for telegraph poles. In speaking of the sanitary effects of the forest he says that "the Landes, which in 1865 were pestilential, are now as free from fever as the most favored regions. The presence of so much wood enables every household to have generous supplies for heating and drying in cold and wet seasons. An investigation of the causes of agricultural depression in other parts of France only too clearly indicates the inestimable benefit of large wood-supplies for domestic purposes."

During the Civil War in America, France enjoyed a broad market for her naval stores at three times the normal price. Owing to the cheapness of the inferior American product, *gemmage* or tapping for resin is not very profitable.

Such was the work started by Chambrelent. By allowing a revolution of thirty years to the pine crops it may go on forever, provided forest fires and insect pests are kept in check. Plantations of coniferous species in all dry countries are always in danger of fire, and forests of one species only are often completely devastated by insects.

By the fixation of the Dunes 650,000 hectares of land were made productive. Formerly if one wished to buy land, he mounted a hill and called in a loud voice; the land over which his voice carried was worth twenty-five francs.

---

* Gardeners often remove the tap-root of trees in order to stimulate the horizontal root system and to facilitate transplanting.

"A man," says Grandjean, "was forced to take some of this sand for a debt. He became a millionaire later by selling it in small parcels." The first summer the visitors lived in the resin cabins; now every luxury is afforded to the two hundred thousand tourists who come there every year.

To-day it is a health resort. It is covered with pines and is prosperous. Although a few severe fires* occur now and then, and owing to a lack of roads or other sufficient means of transportation all the wood is not sold, nowhere in the world, however, are the following industries more extensively and scientifically developed: Collection and manufacture of naval stores, the impregnation of wood with preservatives, and oyster culture. They have also demonstrated that there is no better way of fixing shifting sands, of draining swamps and removing pestilence than by forest-planting.

Destroy completely the forest which covers the Coastal Plain of Eastern America and it will become a bed of shifting barren sand, in places swampy, pestilential, unproductive, unsightly and unfit for habitation, although capable of producing under forest management an abundance of excellent timber and naval stores forever. Large areas of the Coastal Plain of America are rapidly approaching the former condition of the Landes of Gascony.

The eastern coast of America, under proper management, is, in this respect at least, capable of almost limitless prospects. The timber of the short-leaf, long-leaf, old-field and Cuban-pines finds a market even in Europe. Now that yellow-pine (or what they call pitch-pine in Europe) has won a reputation in other countries, it is only good business to see that the supply may not run short, but be more than sufficient for all possible future demands. Besides, there is and, perhaps, always will be more wood used per capita in America than elsewhere in the world. Just as Italy is the land of masons, America is the land of wood-workers, where almost every boy knows how to use a hatchet and a saw.

---

* After several fires in the Montagne Noir comes the announcement of fire in the Landes, spreading from the region of Laborheyre and Parentis-en-Born to Mimizan over thousands of hectares of pine lands An innocent man amused himself burning the herbage in the midst of a country torrified by the heat of dog-days near forests of pine. Hatred and ill-will incited criminal hands to imitate this example. The fire traversed thousands of hectares of forest, as in America, destroying everything in its way. It is astonishing, considering the slight attention accorded to the laws or restrictive regulations, that such disasters should not have occurred earlier, during the great heat of August. At last it rains!—*Revue des Eaux et Forets.* (September, 1898.)

Although the Landes are in the latitude of Nova Scotia, the climate is milder than that of Southern Jersey, so that the resin industry is possible. Arcachon is the combined Lakewood and Atlantic City of France. The largest city in the vicinity is Bordeaux. Just north of Bordeaux, between the Gironde and the Bay of Biscay, is the Medoc, famous the world over for its wines. The soil of this region is, I believe, not unlike that of the Cape May formation of South Jersey. At Verdon, on the point across from the seashore resort of Royan, is a beautiful forest of pine and locust on the dune sand, which was planted by Bremontier. In the forest of La Teste, near Arcachon, is a red marble monument in honor of this famous engineer—a fitting memorial to the man who fixed the sand of these shifting dunes.

In the Landes, in addition to naval stores and timber, oyster culture and apiculture are important industries. Small quantities of cork are also produced. Sheep raising is also an important occupation, and the mules and horses which are produced there, although small in size and tough, are gentle and excellent in quality.

Here and there men and women may be seen spreading boughs and twigs in the ruts of the roads and in the pathways to improve their condition.

The population of this part of France has rapidly increased. Just as reckless deforestation inevitably leads to idleness, want and moral degeneration among those dependent upon the woods, so does afforestation have the opposite effect in the same if not greater proportion. In the Landes, for instance, before the planting of forests a man could buy a farm for a few francs, it required over two acres to support one sheep. In less than a century the population sextupled, while that of a large part of the rest of the country either remained stationary or decreased. A few miserable shepherds were replaced by wood-workers, resin collectors, workers in establishments for refining the product and for impregnating wood, pleasure and health seekers, besides others who were attracted to do other business produced by the change of conditions. The population of a country generally increases in proportion to its natural resources. The fecundity

Plate No. XXVIII.

ARCACHON—THE COMBINED LAKEWOOD AND ATLANTIC CITY OF FRANCE

of the French in places where there is plenty of room and opportunity is proverbial as in Canada. It is even so in the Landes, which, on being reclaimed, was equivalent to the addition of a new province or colony.

The Banat Sand-Desert of Southern Hungary.

Joseph Wessely, in his book entitled "Der Europäische Flugsand und Seine Kultur," gives an interesting description of the Banat Sand-Desert in Southern Hungary. This region is north of the city of Beegrade, which is on the opposite side of the river Danube, in Servia. This great sand-plain was once a lake-bottom before the Danube had worn a deep passage, called the Iron Gate, through the Transylvanian Alps. Even in historic times these shifting sands were covered with forests. In addition to such records there are other evidences which indicate that the region was once forested. These are in the nature of buried beds of humus, lime caves, caused by lime-water settling in cavities of rotted tree-roots, and the names of places, as is often the case in treeless regions, indicate its former wooded nature. The Magyars, for instance, called this sand plain "Nyir" in their names, which signifies "beech."

The soil was not sterile in the sense of lacking inorganic ingredients,* but was of such fine, soft, sandy nature that on being divested of its vegetal covering was easily shifted hither and thither by the wind. Reckless cutting for fuel, the collection of sumac for tanning, and the browsing of many herds belonging to nomads soon despoiled even the few oases of vegetation which existed within recent times. In spite of many efforts to reforest this region, 30,000 of the 70,660 jochen † were bare desert. The greatest evil of all was the flocks and herds which wandered over this region eating the herbage, loosening the soil and exposing the sand to the action of the wind. In addition to these difficulties, there was a revolution in 1848, which interfered with the work of reforestation. Wessely concludes by saying that little had been accomplished because of a lack of knowledge of sand culture and a lack of courageous and unselfish devotion to such work in spite of opposition and difficulties.*

---

* The sand of the fertile marl region of New Jersey is subject to drifting here and there. South of Philadelphia, from the Pennsylvania shore, it may be seen moving in clouds over the fields in New Jersey. The wind picks up the fine grains and leaves the coarse particles behind. This sand blast is, of course, very injurious to fields of young, tender crops.

† "Joch" is an old European land measure. It is the same as "yoke," and originally meant the amount of land a yoke of oxen could plough in a day.

This book appeared in 1873. Since that time there has been great progress. The work in this peculiar and secluded region is of great interest to Americans because it was accomplished under great difficulties, and because it was our own locust tree which was most successfully and extensively planted. In his book Wessely mentions that the Canadian poplar and the locust seemed at that time to be the most promising trees for the region, and that the Hungarian foresters often remarked that "Die Akazie sei in Nord-Amerika für die Ungarische Ebene eigens erfunden worden." †

There has recently appeared an article on the locust by the Hungarian Forester Bund in the *Zeitschrift für Forst und Jagdwesen.* The successful use of the locust on sandy land in the Rhine Province led him to inquire into the experiences with this tree in the Hungarian desert. This tree was at first only used in gardens and along avenues, but soon its good qualities were recognized as a supremely useful cover for sand surfaces. It is to-day principally the locust which relieves the monotony of the Hungarian steppes. In all there are at least 70,000 hectares or about 172,970 acres of pure locust stands in that country. It is, in his opinion, the tree of the future for desert sandy regions. The government is encouraging the planting of this tree by furnishing gratis every year from the State nurseries from five to six million young locust plants.

The chief claims for the use of the tree in Hungary are that its demands on the soil are slight, that it is easily propagated, and that owing to its extensive root-system and root-suckers it holds the soil in place. He recommends that the soil should be worked first, on which a crop of rye or legumes may be grown, and cautions one not to sow seeds which have been scalded or

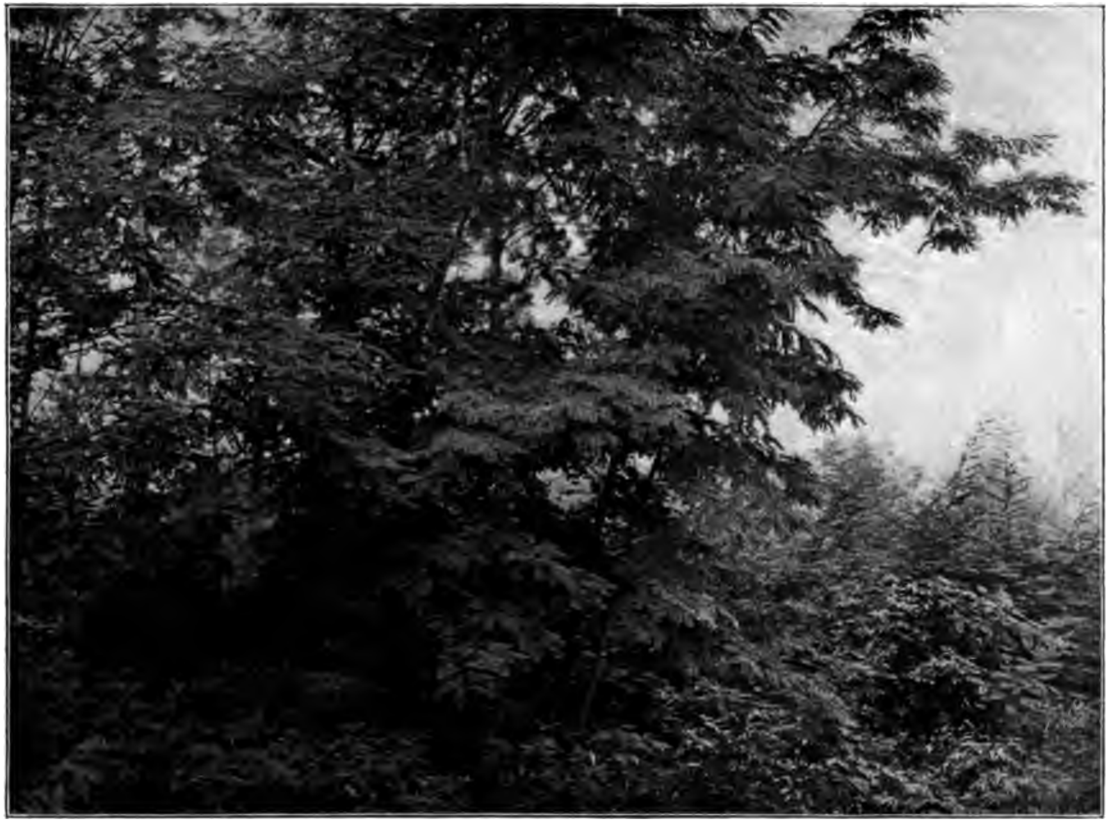
---

* It is worthy of note how that in great reforms much has been accomplished by one or only a very few persistent, enthusiastic workers.

† "The locust has been discovered in America especially for the Hungarian Plain" The term "acacia" is used throughout Europe for the locust tree; in fact, in America, it is called "false acacia," from which comes its specific name "pseudacacia."

REPORT ON FORESTRY

Plate No. XXIX.



THE FOLIAGE OF THE LOCUST

steamed unless the soil is wet. He says that in Hungary the wood is highly prized for many purposes, that the flowers furnish bee food, and that the tree suffers little from disease.

Throughout the Rhine regions the locust is grown as a coppice, with a 15-year rotation. The poles are in great demand for vine-props, and the net return is 80 marks a year for one hectare—a yield scarcely equalled by any other species of tree. The Minister of Agriculture has directed that the locust be planted on land which has been heretofore occupied by coppice oak, since the tan-bark industry is no longer profitable. The American government should offer a high prize to the entomologist who devises a means of exterminating the locust-borer. Were it not for the depredations of this insect the locust would be one of the most profitable and useful of trees for planting on the Jersey sands. It is specially fitted for the purpose because of its slight inflammability.

The Lüneburg and other Adjacent Heath and Moor Lands.

Our prevailing winds are from the land, and in spite of the fact that South Jersey is close to the ocean, the climate is dry in comparison with the plains of Northern Europe. Almost every summer we have a period of extreme drought which is very trying to all plants, the roots of which do not penetrate to where there is a constant supply of moisture. Several species of American trees, such as the red-oak and locust, appear to do better in Western Europe than in their native land, while *Salix amygdalina* and *Salix viminalis* the great European basket willows, which are grown in fields by the side of wheat and rye, fail in the Eastern United States because of the late summer drought.

Throughout a large part of Southern New Jersey, in those portions which are at a low-level and in which the water-table is close to the surface, there is usually a luxuriant growth of vegetation, although the soil may be coarse and sandy. Regions of a higher altitude, such as the Plains, suffer most from a lack of moisture and also from fire in consequence.

Throughout the Sand-lands of Northern Europe there is little variety in the nature of the forest. Wherever there is a clump of woods on upland or lowland it consists of Scotch-pine. Sometimes it is in straight and thrifty condition, but mostly crooked and stunted in nature. There is lacking that variety which one meets with even in the Jersey pine regions, and while there exists a general resemblance between the two regions, closer examination soon shows that in reality they are very unlike. The soil, the climate, the flora, the political, social and economical conditions are all so different that it would be unfair to place the Jersey pine-lands in the same category with these immense tracts of heath and morass which exist throughout Northern Europe.

We should not always assume, however, that because a soil is sandy vegetation will suffer from dryness more than on other soils. This depends altogether on the capillarity [*] of the soil and the proximity of the water-table to the surface. Owing to the cold and a great abundance of moisture peat accumulates in immense beds in Northern Europe. Just to the west of the Ems is the Bourtanger Moor, over five hundred square miles in area, on the boundary between Holland and Germany. Here and there in this morass are firm patches on which the houses of the natives are located, but the most of it is a quaking, treacherous mass of semi-decomposed vegetable matter. The inhabitants crossed this bog-land with leaping-poles. A board was attached to the end of each pole and both people and horses wore wooden "mud-shoes," such as are used on the oyster-beds of France and on the salt marshes of New Jersey. These moors were often so extensive that they served to separate tribes.

The surface of these moorlands was burnt at certain times of the year in order to render them fit for cultivation. The peat-smoke or "moor-rauch," in May, 1857, drifted as far as Vienna, and in July, 1863, to Geneva. In recent times more economical methods have been practiced, and canals have been dug for both drainage and transportation purposes. Wherever the land is imperfectly drained in this region, immense masses of "torf" or

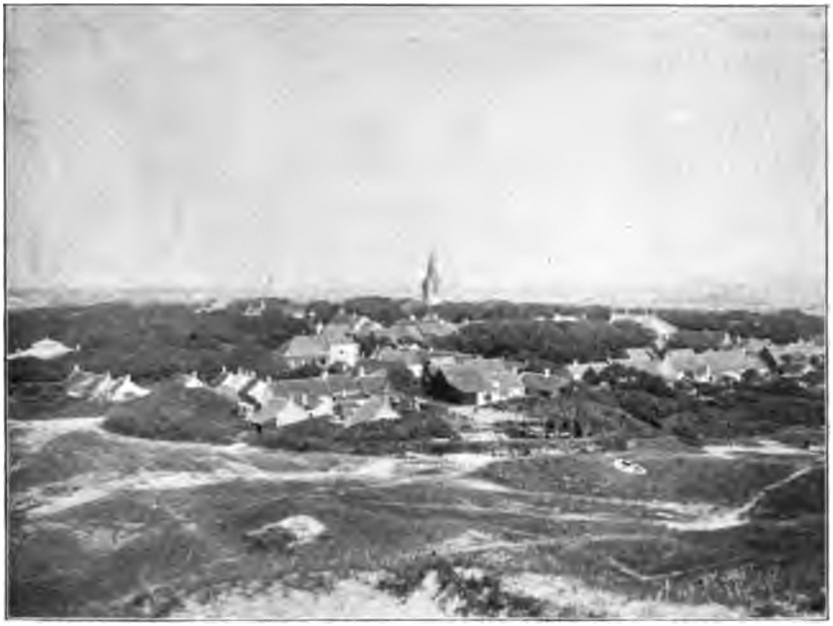
---

[*] In the sand-hills of Nebraska and Kansas, even after long periods of drought, only the few inches of surface-soil become dry. A short distance under the surface the soil is moist to the touch.

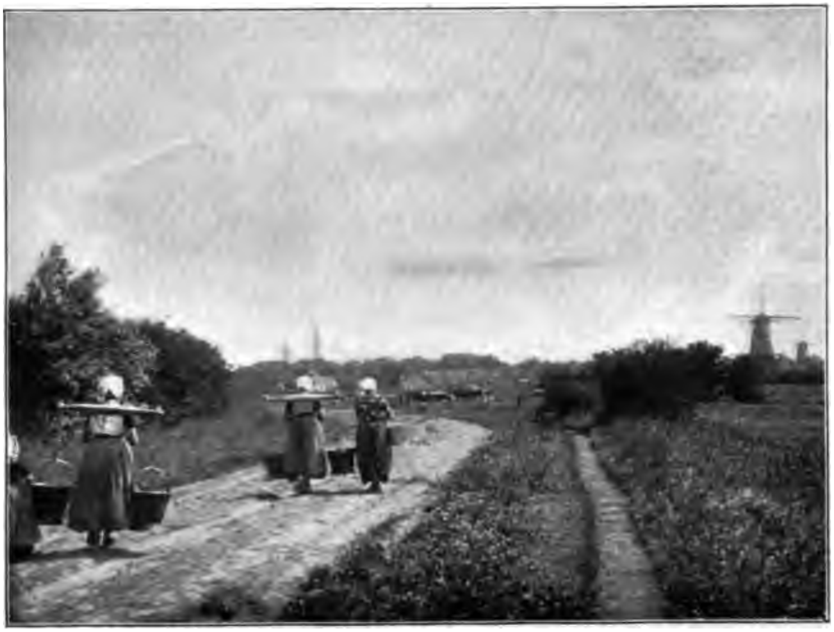
"In the dunes of Algeria water is so abundant that wells are constantly dug in them at high points on their surface. They are sunk at a depth of three or four meters only, and the water rises in them to a height of a meter."—Laurent, *Memoire sur le Sahara*. "The Dunes of the Sahara in some places supply pasturage for the caravans."—Pomel, *L'Annee Geographie*.

The city of Amsterdam is supplied with water from the Coast Dunes of Holland. This is simply rainwater, which soaks into the sand. The Hague also is similarly supplied.

Plate No. XXX.



DOMBERG—A RESORT IN THE LEE OF THE ZEELAND DUNES



A PIECE OF RECLAIMED MARSHLAND IN ZEELAND

peat accumulate. Here and there are dune-like formations on which the Scotch-pine has been planted.

The Scotch-pine is a wonderful tree in respect to its endurance. It grows in the wet cold bogs and on the dry upland. Because of the remarkable endurance of this tree it has been planted in our arid West. The plantations are still young, but in a thrifty and promising condition.

Large portions of the heathland of Northwestern Europe is called "geest," which is high and dry, sandy or gravelly land. The geest which I have seen is gravelly, compact, and covered with a sparse growth of heathplants, and in appearance even more bare and sterile than the Plains of South Jersey. In general appearance it is not unlike the Plains, and I have no doubt but that trees would grow in this region were we to apply the same principles of culture which are applied on the geest lands of Holland and Germany.

The heathlands of Europe have been subjected in times past, and even in places to-day, to all sorts of abusive practices. They have been pastured, or better, overpastured, from time immemorial, and the top-soil has been many times removed by the peasants for litter, as in the Belgian Campine.

The best example of reclamation may be seen at Schovenhorst, near Putten, in Holland, on the Schober estate.* I was most cordially received by Mr. Schober, and he explained how that by thoroughly loosening the soil by deep plowing or spading and then applying the proper kind of fertilizer the abuse of years could be overcome and pine forests once more established, as was evidenced by the beautiful groves consisting of many exotic and native conifers which formed an oasis in the midst of a desert. There are conifers from almost every corner of the earth in healthy condition, forming one of the most remarkable botanic gardens I have ever seen, demonstrating well what may be done by perseverance and skill even where nature is stingy with her gifts.

Perhaps the largest and wildest of these heathlands is the Lüneburger Heath.† It is near the city of Hamburg, south of the Elbe, in the province of Hanover. The general surface is

---

*See "Pinetum Schoberianum," by G. A. Kuyk. Reprint from *Tydschrift voor Tuinbouw.*

†See Kultur der Haideflachen. Salfeld.

undulating, but the northern edge sinks down abruptly so that when viewed from afar it resembles a range of low hills. This is a part of the great North German Plain, which extends from the Ural mountains to the coast, consisting mainly of heath and moor, planted in places with Scotch-pine. It consists of loam, sand, clay, gravel and marl. Here and there are erratic boulders which have been deposited, no doubt, by glaciers. Where the soil is loamy and marly the beech is abundant. "The sand," says Salfeld, "forms scattered hills or great sandy plains from which the clay has been washed by the rains."

In many places the primeval forest consisted of oak and pine. In other regions beds of "ortstein," a sandstone similar to the "alios" of the Landes, prevents drainage and the growth of trees. On such places the heather holds full sway. These are natural steppes and probably have never been covered with trees.

In the Lüneburger Heath there are many small streams, although the region is at times quite dry and parched. The water quickly runs away and the region is exposed to the drying effects of the winds. "A trip across this heath in winter," says Salfeld, "is dreary enough." One meets here and there natives digging up the sods for litter. This exposes the soil to the wind so that it shifts more or less from place to place. Here and there are bee-stands which are used only in blossoming time when the keeper moves from place to place with his hives in search of fresh pastures. Here and there are sheep corrals. The shepherd even in winter may be seen alone with his flock of hardy, small black sheep called "snucken." As with the shepherds of the Landes he knits while his sheep crop the scanty herbage. These sheep live out of doors in winter, even in the snow, and when the lambs come many are killed by the shepherd, because one lamb must suck several mothers on account of the scarcity of food.

Here and there are streams with irrigated and fertilized meadows. Along their banks are alders and on the ridges of sand fringing the meadows are strips of pine to break the force of the wind.

At last we reach a farm. Attached to the straw-thatched house is a yard surrounded by a granite wall. Granite seems out of place here. The origin of the granite boulders from which the walls are made is not, I believe, positively known. The cattle stand knee-deep in a mass of heath-litter and dung. In order to supply this litter an area at least five times the area of the cultivated fields is robbed of its cover. The removal of marl and turf and continuous cropping without rotation have produced a degree of poverty which is often pitiful.

The heath, in fact, is the land of the "little man," that is, the man of small pursuits. Birch and heath twigs are converted into brooms and brushes. Berries are sent to Bremen and Hamburg and are used in the manufacture of wine. Edible mushrooms are assiduously collected and juniper berries are picked for the manufacture of gin. Even the fine roots of the pine are woven into baskets.

According to Salfeld old chronicles and documents give assurance that the geest lands of Northwest Germany were once richly wooded. There are instances of remnants of old and extensive forests. "The extent of the forest was measured," says Salfeld, "by the length of time a squirrel could pass through it by leaping from tree to tree." These forests were of deciduous trees. They have been supplanted by the pine, owing to the gradual impoverishment of the soil. Storms, fire and insects played havoc in these coniferous woods, and swineherds and shepherds wandered at will with their flocks. There was great eagerness to clear the land for fields and meadows. The end has been reached, and now begins the long, tedious and expensive work of reforestation, which is the only salvation for abused and depleted sand-lands.

All this illustrates well the fact that unless the forest plays a part in the rotation of crops on sandy land it is only a question of time before the soil becomes absolutely sterile.

This land is being reclaimed first by deep ploughing,* which thoroughly loosens the soil and brings the richer subsoil to the surface.

The second step is in planting a leguminous crop for green manure. For this purpose the yellow lupine, what is called in Brandenburg "the gold of the desert" is used. This does not grow in America, but we have many others which will answer the same purpose.*

---

* The work of reclaiming the Lüneburger Heath did not begin in earnest until 1870. It will be many years before the plantations will become remunerative. The growth is slow and the cost of reclamation high. Of late years steam ploughs have been extensively used in order to thoroughly loosen the soil.

The third step is the planting of pines.

The fourth step, and the ideal stage, as far as the fertility of the soil is concerned, is the production of a rich, dense forest of the broad-leaved trees, such as the Forest of Compiegne, which is pictured in the frontispiece of this report.

Forestry in Denmark.

Nowhere in Europe is forestry more intensively developed than in Denmark. These practical people waste no time in advertising what they have accomplished. They have been working more for financial gain than for glory. There is a commendable lack of sophistry and impractical notions in reference to their forest management. It is not my intention to attempt to describe their methods in this connection, but no place is more worthy a visit by American foresters. For many years these enterprising people have been at work developing a system of their own. They have been practically unnoticed by foresters until recently, when their methods were described by Dr. Metzger, in the *Mündner Hefte*. Several writers on the continent are endeavoring to show that the Danish system is after all old, and has been elsewhere in practice more or less for some time. Even if this may be so, the Danes were the first to fully appreciate its advantages and put it into execution. They have been quietly "sawing wood" while their neighbors have been holding learned discussions. The Danish foresters long ago traveled throughout Europe, absorbed what they needed and evolved from it a system of their own, adapted to the peculiar conditions of their little country. They were particularly influenced by what they saw on some private estates in England. They show, indeed, the same amount of intelligence in everything they attempt. Their dairy industry is a model, every man and woman can read and write, and every traveler to their country is impressed with the fact that they are an honest, solid, wide-awake, up-to-date people.

---

* The sandy soils of the Pines are in need of humus and green manuring. For this purpose there is no better crop than *Lupinus perennis* which will grow where other leguminous crops fail. The plants of this genus were named *lupinus* from *Lupus*, a wolf, because it was thought that they devoured the fertility of the soil. Nothing could be farther from the truth. The *perennial lupine* of Southern New Jersey is one of those pioneer plants which in the midst of the sand is paving the way for less hardy species.

The forests of Denmark are of special interest to Americans because a large percentage of the forest is owned by private parties. The excellent system of forest management is the result of private enterprise. Only six per cent. of the country is wooded. These woods are mostly on the islands. Jutland is mainly heathland. The soil of the country is sandy. A calm day is rare, and without eternal vigilance and care a large part of the country would blow or wash into the sea.

The production of Danish forests is high. They produce 4.8 cubic meters of wood per year per hectare. The highest yield in Germany is in Erfurt, which is 4.5 cubic meters.

The ease of importing both coal and wood cause great competition. Denmark is near to Norway and Sweden, which are great exporters of wood, and near to England, a great exporter of coal. Sixty per cent. of the Danish forests are beech, which is used for fuel, butter-tubs and wooden shoes; seven per cent. is oak, which is used for ship building, and twenty-one per cent. conifers. The Danes have outgrown the notion that conifers are preferable to hardwoods. Even the forestation of heathlands with conifers is regarded a necessary evil, and they cherish the hope that some day the soil will be fit for hardwoods.

The wood is sold direct to the purchaser without auction, and the foresters are more on the order of enterprising business men than mere administrative officers who spend most of their time at the desk writing reports. The position of chief forester in Denmark requires a knowledge of commercial principles and business skill. These men are granted much freedom and confidence by their employers. They receive a share of the profits and are therefore financially interested in every operation.

There is no great secret to their methods. It is simply the application of great skill and economy. They simply do what pays the best; that is, employ those principles of business management which produce the largest returns in the shortest length of time, preserving at the same time a sustained yield and desirable soil conditions.

The Danes are great believers in pure stands, and instead of producing 500 spindling oaks on a hectare of land, are content with 200 sturdy, well-crowned specimens, because it pays.

Great attention is paid to the soil. Their aim is to keep the surface covered with a coating of damp, mellow leaf-mold. They are the friends of the earthworm, and do everything possible to encourage this assiduous little animal, which does good work in keeping the soil loose and mellow.*

Very careful protective measures are necessary throughout Jutland, because of the winds. Wind-breaks of trees and shrubs, and turfed earthbanks are necessary, otherwise the winds would shift the soil from place to place.

Metzger describes a beech forest 300 meters from the sea. The outer edge consisted of an impenetrable hedge of clipped beech, ten meters in width. The soil was full of earthworms.

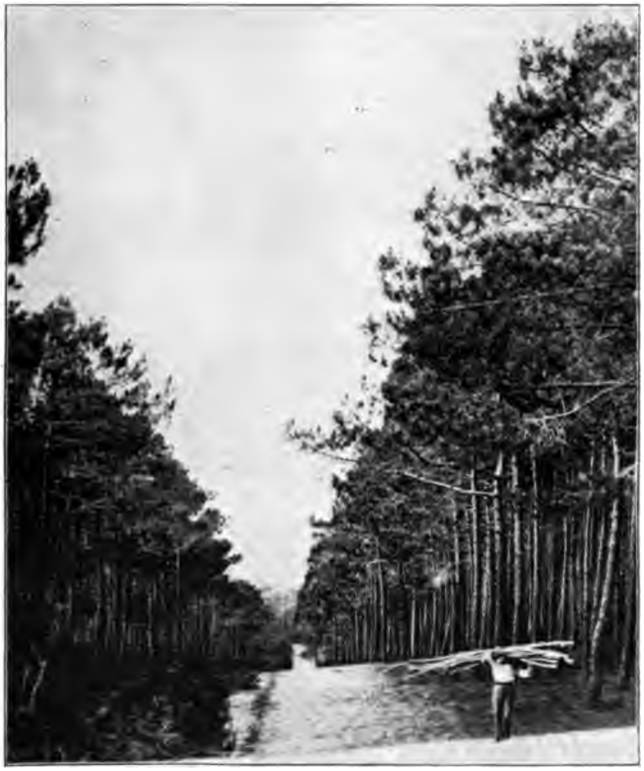
No peasant rights or onerous servitudes exist in Denmark. The Danish foresters do not combine hunting with their profession. They carry a spade rather than a gun. In short they are the Yankees of Europe, from whom we can learn many things.†

---

* The importance of soil aeration is often overlooked by foresters and soil cultivators. When a large forest fauna is present, especially earthworms, the soil is kept mellow and sweet, and hardpan and peat are less apt to form. When there is an abundance of these animals in the soil, it is usually an indication that the soil is in good condition.

† In the use of scientific names of trees in the above I have been guided by the "Check-list of the Forest Trees of the United States," by George B. Sudworth, Division of Forestry, Dept of Agriculture, Washington, D. C.

Plate No. XXXI.



A FIRE-LANE IN THE PINERY ON THE DUNES OF GASCONY

INDEX.

INDEX.

A.

Page

Acorns, Use of 261
Ailanthus Tree 242
Alamuche-Pohatcong Range, Forests on 47
Angiospermæ Deciduous Zone 185
Ants, White, in Dead Wood 223
Apple Borer, Round-headed 219
Arboreal Species. See Tree Species.
Area of Forests 16
Arid Conditions and Deforestation 172
Atlantic County, Clearings in 19, 98
Avalon, Trees Engulfed by Sand 250

B.

Bailey, Prof., Reference to 287
Banat Sand-Desert 309-311
Banked Meadows 248
Bark for Tanning 257
"Bark Beetles" in Forest Trees 211
"Bark Slippers" in Forest Trees 223
Barren Water-sheds, Little Capacity for Absorption of Rain-fall 161
Beaches, Sea, Forests on 251
Beaches, Sea, Mode of Formation of 250
Beach Glen, Timber About 62
Beach Plum 260
Beacon Hill Formation and Pine-Lands 302
Bearfort Mountain 15
Bearfort Mountain, Fires on 59
Becqueral, Antoine C., Reference to 138
Bee-keeping and Forests 291
Beetles, Rhinoceros, in Tree Stumps 226
Belgian Campine, The 296-302
Bergen County, Forests in 16, 65, 81, 83-87
Bergen County, Timber in 28
Berry-picking and Forest Fires 269
Birds, Value of, to Forests 231
Blueberry High-bush, in Swamps 259
Coonton, Forests North of 63
Boring Insects in Forest Trees 217
Bowling Green Mountain, Timber on 56
Bremontier, Reference to Work of, in France, 303, 308
Briars and Bushes in Swamps, *Note* 278
Bridgeton, Fossil Plants at 197
Britton, Dr. N. L., Reference to Catalogue of, 179, 192
Budd's Good Order in New Jersey, Extract from 2

Page

Burlington County, Forests in 16, 96, 113, 125, 238
Burned Trees, Removal of 230
Burlap Bands Against Insects 232
"Bush"—Origin of the Term, *Note* 253

C.

Caldwell, Forest near 81
Campine, The Belgian 296-302
Carolinian Life Zone 236
Catchment Basins, Deforested 149
Catchment Basins, Relation of Shape to Discharge 155
Catchment Basins, Table of 145
Caterpillars in Forest Trees 206
Cedar-Apple, *Note* 284
Cedar, Red, on Palisades Range 84
Cedar, Red, for Plantations 284
Cedar, Red, on Red Shale 93
Cedar, Red, on Watchung Mountain 83
Cedar, White, Swamps 245
Cedar Swamps, Effect of Fires on 104
Cedar Swamps, Timber on 29
Cedar-swamp Land, Value of 26
Cedars and Pines in Clearings 183
Cedar, White, Habit of Growth 131
Cedar, White, Reproduction of 132
Cedar, White, Situation and Soil 131
Cedar, White, Valuation Surveys of 133
Cedar, White, Yield of 134
Cedar, White, Silvicultural Notes on, by Gifford Pinchot 131
Cedar, White, Rate of Growth 36, 38
Cedar, White, Mining of 255
Cedar, White, Great Age of Logs of 256
Cedar, White, Lumber 245
Cedar, White, for Forest Plantations 286
Census Reports of Forests 18, 33
Chamæcyparis, thyoides (White Cedar) 245
Chamæcyparis, thyoides, Areal Distribution of 189
Chamæcyparis, thyoides, for Planting 286
Chambrelent, M., Reference to Works by, 303, 305, 306
Charcoal, Making 255, 275
Chester, Timber South of 74
Chestnut Trees, Large 36, 54
Chestnut, Soils Favorable to 37
Chestnut, Absence of, on Red Shale 71, 91
Chestnut Tree, Value of, *Note* 281

Page
Christmas Trees 260
Clarke, W. K., Notes by 63
Clay and Marl Formations, Plant Life of 195
Clearings, Extent of 18
Clearings on Borders of the Pines Belt 96
Clearings in Pines Belt 98
Clearings, Pines and Cedars in 183
Clearings of Indians 253
Clearings of the Early Settlers 254
Climate, Effects of Forests on 8
Climate and Forests 167
Climate of the Pines 171
Climate of South Jersey, Effect of Forests on.. 266
Coastal Plain, Forest Conditions of, by John Gifford 233
Coastal Plain, Limits of 235
Coastal Plain, Soil of 237
Coniferous Forest Border in Southern Counties 95
Coniferous Forest Zone 179, 182
Coniferous Zone, Tree Species in 185
Conifers and Hardwoods 317
Coniferous Trees, Humus Under 105
Coniferous Trees left in Cutting 59
Copperas Mountain 15
Copperas Mountain, Forest Growth on 60
Coppice, Oak, in Pine Barrens 242
Coppice, Pine 239
Coppice Growth on the Plains 126–130
Coppice, System of Forest Treatment 277, 280
Coppice Wood in the Highlands 21
Cottonwood for Forest Plantations 287
Cord Wood and Insects 223, 230
Cord Wood 257
Counties, Area of Forests in 16
Cranberry, Production of 259
Cranberry Bogs, *Note* 246
Cretaceous Period, Plant Life of 194
"Cripple," Definition of Term, *Note* 247
Cumberland County Forests, Clearings in 19
Cushetunk Mountain, Timber on 93
Cutting on Southwestern Highlands 71
Cypress, Bald 181

D.

Deciduous Forest Zone 179, 182
Deciduous Zone, Tree Species in 185
Defoliation of Trees by Insects 206, 229
Deforestation of the Pines Belt, Dangers of.... 40, 301, 307
Deforestation and Rain-fall 170
Deforestation and River Heights 143
Deforestation in South Jersey, Effect on Population 291
Deforestation and Temperature 171
Deforested Areas 18
Deforested Catchment Basins and Evaporation 149
Deforested Districts and Rain-fall 168
Deforested Red-shale Country 92, 93
Deforested Valleys in the Highlands 69, 73

Page
Delaware, Great Floods in the 159
Denmark, Forestry in 316-318
Desert Conditions and Deforestation 40, 170
Dickerson, C. S., Notes on Timber by 64
Diospyros Virginiana 259
Dismal Swamp, Timber in 90
Dismal Swamp, Trees in 32
Distillation Products from Wood 258, 275
"Doated" Wood 214
Dover, Forests South of 73
Droughts and Forests 139, 164, 172
Droughts, Occurrence of 170, 172
Droughts on Sandy Soils 311, 312
Dunes, Coastal, Formation of 304
Dunes, Coastal, Vegetation on 251
Dune-lands of France 302-309
Dykes (Sea) *Note* 249

E.

Eastern Peninsula of Maryland, Pine Forests on 261, 300
Earle, Ezekiel, Notes From 63
Ebermayer, Prof., Quoted 105
Ebermayer, Prof., Reference to Observations of 151
Education and Forests 9
Elm-leaf Beetle 207
Essex County, Forest in 16, 76, 81–83, 84
"Esterel," The, in France, *Note* 269
Europe, Parts of, Similar to Southern New Jersey 293
Evaporation, Effect of Forests on 139
Evaporation, Relation of, to Rainfall and Temperature 148
Evolution of Flora 193

F.

Farmingdale, Deciduous Forest at 187
Farms, Unimproved Land in 18
Farms, Wood-lots in Small... 21, 262, 270, 288-291
Fire-lanes, Necessary 40, 269, 270-273
Fire-lanes and Public Roads 272
Fire-lanes in Gascony, France 305
Flemington, Original Forest Southwest of 94
Floods, Conditions of Maximum 152
Floods, Effect of Forests on 137
Floods, Examples of Great 154, 159
Floods, Relation of, to Forested Areas 164
Flora, Older Geologic, and Existing Species... 193
Fontaine, Prof. Wm. M., Reference to 195
Forests, Extent of, and Area 15, 16, 17
Forests, Progress of Clearings and Changes, 18, 23
Forests, General Conditions 20
Forests, Field Notes on 45
Forests of the Highlands 46
Forests in Red Sandstone Zone 21
Forests in Southern Part of State 95–100, 113–135, 181, 231

Page
Forests on Trap-Rock Ridges.......76, 80
Forests, Conditions of, in the Coastal Plain.... 233
Forests on the Sea Beaches........ 251
Forests, Original, in Southern New Jersey, 109, 113
Forests, Original, Examples of........85, 91, 94
Forests and Second Growth........110, 120
Forests, Tree Species and Zones........ 185
  Tree Species and Geological Formations........177, 190
  Tree Species and Historical Development........ 193
  Tree Species, Examples of Distribution........186, 188-190, 236-237
  Tree Species, Succession of Growth, 86, 243
Forests, Tree Species, Changes in........ 200
Forests, Zones of........178, 182-190
Forests, Relation to Soils—
  General........ 178, 184, 191
  Improvement of Soils by........ 262, 267
  On Old Fields........ 98, 226, 283, 300
  Use of Forest Litter of........ 261
Forest Production and Valuation—
  General........ 23, 33
  Value of Standing Timber.....25, 55, 66, 85
  Relative Productiveness........ 32
  Valuation Surveys........ 33, 110
  Effect of Fires on........ 109
  And Land Valuation........ 27, 66
  Products........ 258, 274
  Revenue by Planting........ 279
Forests and Role of, Insects in—
  General........ 203
  Care of, Against Insects........ 229
  Use of Sprayers........ 231
Forests and Climate—
  General Notes........ 167, 266
  Arid Conditions........ 170
  And Rainfall........ 168
  Droughts........ 164
  And Temperature........ 168
Forests and Health—
  Climate, Mild in Pines........ 171
  Hygienic Effects of........ 292
  Planting and Health........ 306
Forests and Water-Supply—
  General........ 137
  On the Purity of Water........ 165
  On Evaporation........ 139
  On Seasonal Rainfalls........ 168
  On Equalizing Stream Flow........ 160
  On Maximum and Minimum Stream Flow........ 152
  On Great Floods........ 164
  Forested Catchment Basins........ 150, 163
Forests, European, Planted—
  In Belgium Campine........ 296
  In Denmark........ 316-318
  Landes in France........ 302-309
  Hungary........ 309-311
  Lüneburger Heath........ 313

Page
Forest Policy........41, 265
Forest Management........ 41
Forest Management, Systems of........ 277
Forest Management and Private Control, 265, 267
Forest Management and Small Holdings........ 262, 270, 288-291
Forest Management and State Control........ 11
Forest Management and Taxation........ 276
Forest Buried Under Dune Sand........ 250
Forest Preserves........50, 62, 67
Forest of Compeigne........ 316
Forests, Historical Notes of........ 2
Forests, Æsthetic and Educational Value of... 10
Forest Fires, Losses Due to........39, 100, 109
Forest Fires, Effect on Second-growth, 103, 120-123
Forest Fires and Insect Pests........ 211
Forest Fires Set by the Indians........ 253
Forest Fires, Effect of, in White Cedar Swamps, 104, 247
Forest Fires on the Plains........ 129, 241
Forest Fires in Southern New Jersey........ 268
Forest Fires on the Landes, France, *Note*........ 307
Forest Fires, Moral Effect on Population........ 107
Forest Fires, Necessity of Protection Against, 11, 39, 268
Forges and Furnaces, Use of Wood by........ 20
Forges and Furnaces in the Pines........22, 255
Fox, Col. William, Reference to, *Note*........ 253
Fox Hill District, Timber on........ 75
Fossil Plants at Bridgeton........ 197
France, Dunes and the Landes of........ 302
French, James, Management of Woodland by, 50
Fruits, Wild, in Forests........ 259
Fuel, Wood, consumption as........ 23
Fuel, Wood for, Kinds of........ 257
Fuel-wood, Use of........ 274

G.

Galls on Forest-leaves........ 206, 208
Game Preserves........50, 62, 67
Gascony, Dunes and Landes of........302-309
Geologic Formations and Tree Distribution........ 190
Geological Divisions and Forests........17, 46
Geology, Relation of Forestry to........ 1, 177
German Valley, Deforested........ 72
Germany, Lüneburger Heath and Other Heath-lands........311-316
Gifford, John, Report of........ 233
Gifford, John, Statistics of Fires by........ 101
Glacial Epoch, Plant Life of........ 199
Goat Moth, Injuries of........ 215
Gordon's Gazetteer, Extract from........ 3
Grandjean, M., Reference to Works of......303, 307
Great Swamp, Timber in........ 79
Greenpond Mountain........ 15
Green Pond and Copperas Mountains, Timber on........ 60
Growth of Trees, Rate of........ 34
Grubs, White, in Dead Forest Trees........ 226
Gymnosperms, Waning of........ 200

H.

Page
"Hackensack" Valley, Forest in.................. 83
Hammonton, Farm Lands in Pines at....... 98, 302
Heath Lands of North Germany...............311-316
Healthfulness Promoted by Forest Planting... 306
Hibernia, Timber About.............................. 62
Hickory, *Phylloxera*, Galls on.......................... 209
Hickory, Bark-beetle.............................. 211, 218
Highlands, Clearings in................................. 19
Highlands, Chestnut Timber in........................ 20
Highlands, The, Coppice Wood in.................. 21
Highlands, Forests on the.............................. 28
Highlands, Notes of Forests on....................... 46
Highlands, The, Profits of Timber in............ 20
Highlands, Cutting of Timber on.................. 75
Historical Notes of Forests............................ 2
Holland, Forest Experiments in.................... 293
Holland, Waste-lands in.............................. 293
Hollick, Arthur, Report of............................. 173
Holly, American, on the Beaches.................. 251
Hook Mountain, Wood on.............................. 77
Hoop-pole Splitting...................................... 256
Hopatcong Lake, Timber About..................... 56
Hopewell, Timber Southwest of..................... 92
Huckleberry, in Swamps............................... 259
Humus, Destruction of, by Fires.................... 105
Humus, Effect of, on Springs........................ 137
Humus, Influence of, in Forests.................... 161
Humus, Value of, to soil................................ 106
Humus in Forest, Value of, *Note*.................. 262
Hungary, The Banat Sand-Desert of.............. 309
Hunterdon County, Forests in..16, 71-72, 75, 92-95
Hunterdon Plateau, Forest on........................ 94

I.

Ilex Opaca, Areal Distribution of.................. 189
Indians, Clearings Made by........................... 253
Insects, the Role of, in the Forest.................. 203
Insects, Injury to Timber............................... 211
Insect Borers on Locust Tree......................... 220
Insects in Cord-wood.............................223, 230
Insect Pests Destroyed by Fowls.................. 291
Insecticides, Use of, in Forests.................... 231
Iron-making and Forests............................... 20
Iron-making in the Pines............................... 255

J.

Jenny Jump Mountain, forests on.................. 52
Job's Swamp, White Cedar in........................ 133
Juniperus Virginiana, for planting.................. 284
Juniperus Virginiana. See also, "Cedar, Red."

K.

King, Prof. F. H., Reference to Report of, 140, 142
Kittatinny Mountain...................................... 15
Kittatinny Valley, Woodland in........ 18, 49, 68, 69
Kittatinny Valley, Variation in Rainfall in...... 168

L.

Page
Landes, The, France.................................. 302-309
Larvæ on Forest-tree Leaves........................ 206
Laurel on the Plains...................................... 240
Lawes & Gilbert, Reference to Experiments of...140, 142
Lice, Plant, on Forest Leaves........................ 210
Liriodendron Tulipifera, soft scale on........ 210
Litter of Forest, Use of................................. 261
Locust Tree and Insect Borers...................... 220
Locust Tree for Plantations.......................... 285
Locust Tree Plantations in Banat Sand Desert.. 310
"Lumber" and "Timber," Use of Terms, *Note*... 258
Lumber, Insects in.. 224
Lumber Product of State............................... 24
Lumber Product, Future................................ 274
Lumber, White-Cedar, Value of............134, 286
Lumber, White-Cedar, Mined........................ 255
Lüneburg Heath-lands, Germany.................. 313

M.

Managers, Board of, as Forest Commission..... 12
Manahawken Swamp, White Pine in, *Note*...... 247
Marshes, Salt.. 248
McAdam, William, Notes on Timber by........ 80
McDowell Tract, Timber on.......................... 93
Meadows, Banked.. 248
Mercer County, Forests in............................. 92
Merriam, Prof., Reference to........................ 236
Mesozoic Time, Plant Life of........................ 194
Middlesex County, Timber in Northeast part of.. 89-90
Milton, Valley at, Timber in.......................... 60
Mine Mountain, Forest on............................. 74
Mohr, Dr. Charles, Reference to.................. 282
Moisture, Influence of, on Rate of Growth of Trees.. 37
Monmouth County, Woodland in.................. 96
Morris County, Forests in..16, 55-65, 70, 72-75, 76, 80, 81
Morris Plains, Timber About.................74, 77
Morristown, Timber Near.................74, 77, 78
Moss of Swamps, Use of.............................. 260
Mount Hope, Timber Near............................ 62
Musconetcong Mountain, Forest on.............. 71
Musconetcong Valley, Deforested................ 69

N.

Natural Parks, Necessity of.......................... 10
New Albion, Ployden's, Reference to............ 2
Newberry, Dr. J. S., Reference to Monographs of.. 194, 196
New Lisbon, Original Pine Forest at............. 115
Nuts and Acorns of Forest........................... 261